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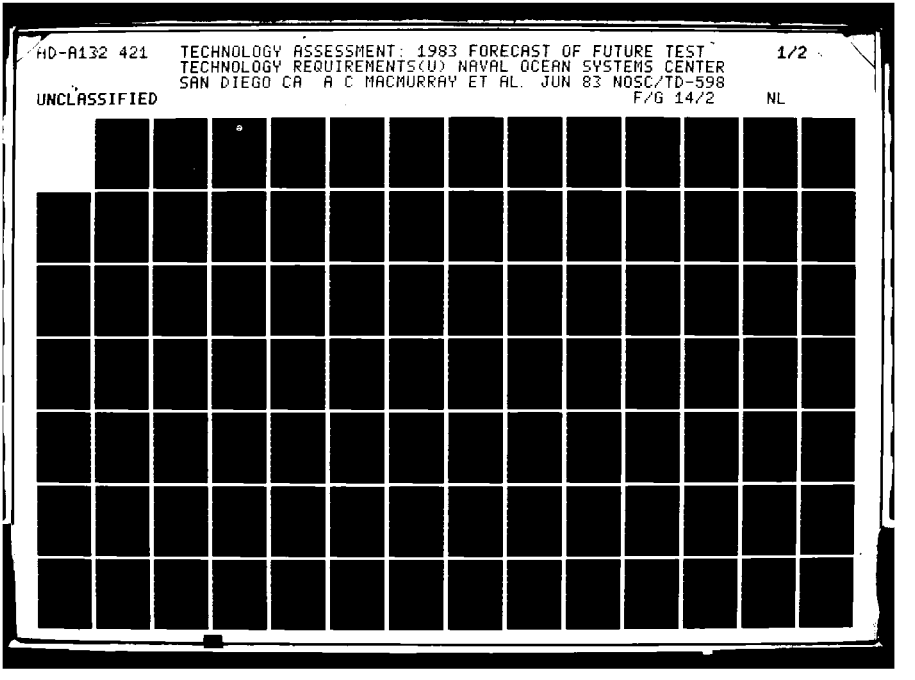

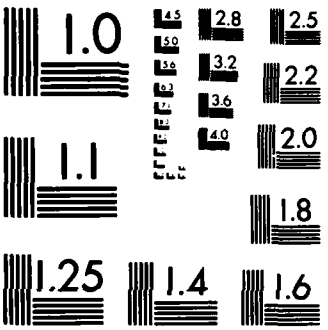

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

NOSC TD 598

Technical Document 598

TECHNOLOGY ASSESSMENT
1983 forecast of future test technology requirements

A. C. MacMurray
V. D. Leonard

June 1983

Research Report: October–May 1983

Prepared for
Chief of Naval Material

Approved for public release; distribution unlimited

NOSC

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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Within the Joint Logistics Commanders Automatic Test Equipment Program the Navy is assigned the task of monitoring emerging technologies. Monitoring emerging technologies includes assessing and evaluating potential impacts upon future test capabilities. This assessment of research, exploratory development and advanced development categories of research and development was accomplished within the Navy as a pilot project. The next phase will be a tri-service assessment. It is the intent of this document to provide industry and government an overview of potential influences that need to be considered in test technology research and development.

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TABLE OF CONTENTS

ACRONYMS

ALL	Air Laser Laboratory
A-O	Acousto-Optical
AT	Automatic Testing
ATE	Automatic Test Equipment
BIT	Built-In-Test
CW	Continuous Wave
DSC	Digital Scan Converter
EAR	Electronically Agile Radar
E-O	Electro-Optics
FET	Field Effect Transistor
FLIR	Forward Looking Infrared
GaAs	Gallium Arsenide
HEL	High Energy Laser
IC	Integrated Circuit
IR	Infrared
IRST	Infrared Search-Track
JLC	Joint Logistics Commanders
LJARS	Laminar Jet Angular Rate Sensors
LPA	Laminar Proportional Amplifier
LPI	Low Probability of Intercept
LPIR	Low Probability of Intercept Radar
LRU	Line Replaceable Units
LSI	Large Scale Integration
M-P	Microprocessor
MMW	Millimeter Wave

MSSW	Magnetostatic Surface Wave
MW	Microwave
NBS	National Bureau of Standards
NDE	Non-Destructive Evaluation
NDT	Non-Destructive Test
NMMW	Near Millimeter Wave
PRF	Pulse Repetition Frequency
PSP	Programmable Signal Processor
RAM	Random Access Memory
REF	Reformatter
RPV	Remote Piloted Vehicle
SAW	Surface Acoustic Wave
SCM	Signal Conditioner Miltiplexer
SPS	Scan Position Sensor
SQUID	Superconducting Quantum Interference Device
STM	Service Test Model
TWA	Traveling Wave Amplifier
TWT	Traveling Wave Tube
UV	Ultraviolet
VCID	Voice Control Input Device
VLSI	Very Large Scale Integration

PREFACE

The Joint Logistics Commanders (JLC) Panel on Automatic Testing (JLC-AT) tasked the Naval Ocean System Center (NOSC) to assess emerging R&D technologies for impact upon the testing and calibration technologies. The most probable test problems will be candidates for JLC tri-service funding to develop new test instrumentation and techniques. Historically, although new test equipment requires nearly as long to develop as the military equipment it is intended to support, it enters the development cycle quite late. If new test technologies are required, the test equipment will not be available for years after the weapon system enters the field and, on many occasions, expensive contractor field support is required to fill the gap for the life of the weapon system. This assessment will highlight potential problems and required research. Current military equipment in the field operates in the microwave and low gigahertz frequency ranges with pulse and data rates that already strain the capabilities of present test equipment. Emerging R&D DoD technologies contacted in this effort are extending the range of measurement parameter requirements in future military systems into the terahertz (10^{12}) frequency and femtosecond (10^{-15}) data rates. These military technologies now in the 6.1 through 6.3 funding categories of research could become operational systems in the next five to 15 years.

This effort surveyed the currently funded DoD technology development projects to identify possible future test problems and present these problems to the JLC test technology committee.

This task entailed assessment of all tri-service RDT&E projects presently within DoD 6.1, 6.2 and 6.3 funding categories that are:

- o Unclassified
- o Reported on work unit information summaries, form DD1498
- o Within 69 broad scientific and technological areas selected from DoD INST 7220.16
- o Funded for FY 1982 as follows:

  6.1 $20K
  6.2 and 6.3 $100K

NOTE: The funding criterion was waived for some viable programs that were temporarily underfunded and likely to be refunded shortly.

SECTION 1

PERFORMING TECHNOLOGY ASSESSMENT

The Defense Technical Information Center (DTIC) data bank was chosen as the source for raw R&D information. Sixty-nine scientific and technological area codes were selected from the listing provided by DOD INST 4720.16 as having a probability of test difficulty. Only categories 6.1, 6.2 and 6.3 type R&D tasks were considered because tasks in 6.4 and systems in service are at a point of having discovered their test technology problems and are developing "work around" solutions.

Initially the R&D task screening criteria were based on the current FY funding level according to 6.1-3 categories. This eliminated some potential test problems due to missing information on the R&D task blocks or lack of current FY funding information. Therefore, the written objective, approach and progress block were made the deciding factors for inclusion or rejection. This proved to maximize output productivity of screening and minimize the possibility of overlooking potential test problem technologies.

A total of 5362 R&D tasks was categorized as potential test problems that were test related or rejected or required follow-up action. During later filtering or follow-up actions, R&D tasks were sometimes changed from one category to another. The three categories are detailed below.

A documentation sheet was compiled in Appendix A for each R&D technology that appeared to present a testing problem. These sheets identify a point of contact with the task's objective, approach and progress, as well as document the follow-up action taken and resultant conclusions and recommendations based on the follow-up action.

A documentation sheet was compiled in Appendix B for each R&D task that appeared to provide potential solutions to testing problems or was a definite test technology development effort. Documentation sheets are similar to those described in preceding paragraph except for the follow-up action which was not required for this grouping of tasks.

R&D work units not meeting the basic R&D evaluation criteria were rejected and no further assessment made.

For correlation and continuity, the various tasks were consolidated under the technology categories used in the 1980 Navy technology assessment. These categories were, in turn, broken down into technology subcategories. Figure 1 shows the five major technologies and their subcategories

SYSTEMS TECHNOLOGY

- Test ECCM*
- Radar*
- Control*
- Materials Test

COMPONENTS TECHNOLOGY

- Superconductors*
- Cryogenics*
- MMW*
- Voice Simulation*
- Digital Scan Converter*
- Nuclear Gyro*
- GAAS Devices*
- Experimental Tubes*
- Magnetostatic Wave Device*
- Electro-Fluid Converter
- Fluidic Rate Gyro
- Quick Reaction Power
- CCD

TRANSMISSION ELECTROMAGNETIC TECHNOLOGY

- High Energy Beam*
- High Power*
- Microwave
- Gyrotron*
- Particle Beam*
- Gyrocon*
- Adaptive Arrays

ELECTRO-OPTIC TECHNOLOGY

- Millimeter Wave*
- Laser*
- Helmet Display*
- Optic Processing*
- Infrared Startle*
- Biological Attack Detect*
- Holographic
- E-O Contrast Monitor

ACOUSTICS TECHNOLOGY

- Acousto-Optics*
- A-O Signal Processing*

*Probable major test problems

Figure 1. Overview of all follow-ups in Appendix A.

SECTION 2

TECHNOLOGY ASSESSMENT RESULTS

Many users may wish to key their use of this R&D test survey by service branch or particular platform. This could not be done in this document due to the across-the-board application of generic R&D technologies such as MMW or lasers to all service branches and numerous platforms such as helos, fixed wing aircraft, tanks, ships and so forth.

Appendix A contains details of the R&D tasks which were contacted, many of which were assessed as future test problems. Many instances were indicated of R&D experiments exceeding the capability of test equipment parameters of speed, frequency, power and temperature. Many R&D organizations used specially designed or "jury rigged" laboratory arrangements as test instrumentation. The capabilities of laboratory type equipment are severely compromised whenever included in large ATE systems due to the excessive interconnect cabling, connectors and switching required. An even greater problem is found when laboratory type test equipment is repackaged as mobile military field equipment. Measurements accomplished easily at the upper extremes in a laboratory will tend to be more difficult, of lower resolution and more subject to error in the field. They might be a part of a large ATE system due to such things as the environmental effects on noise and signal/power loss.

A summary of meaningful comments from R&D project managers and engineers from selected representative R&D tasks are listed below. In some cases there was a difference of opinion as to whether or not test problems exist, for example, TWT and MMW, and these questions need to be resolved. If the details of these problems are desired to be followed up by other agencies, the names and telephone numbers of each point of contact are also in Appendix A.

- The projected test problem areas of cryogenic temperature and superconductor devices are really interrelated. Liquid helium temperature measurement is a different test technology than measuring superconductor parameters of low voltage level, high speed and magnetism. The low kelvin cryogenic temperature measurement also is complemented by needs for pressure and flow rate instrumentation in a liquid helium medium.

- A superconductive A-D converter had the Josephson junction problems amplified by a 24 gigabit/sec data rate.

- Cryogenic switches have a low kelvin liquid nitrogen temperature but voltage levels similar to silicon devices.

- NMMW gyrotron at higher 120 and 240 GHz frequency, "high end of MM world, needs instrumentation."

- MMW equivalents to existing microwave ATE are needed.

- Portable field ATE for MMW is considered impossible by nearly all activities currently developing MMW technology.

- Off-the-shelf MMW test sources and receivers in ranges above 100 GHz are unavailable and are not even in design.

- Lab test equipment for MMW Integrated Circuits (ICs) would not be feasible in a production situation.

- NMMW optically pumped sources have MMW frequency and power intensity measuring difficulties with the frequenc and power parameters.

- The traditional microwave (MW) test methods utilized r decades by engineers should be replaced by new MMW testing ware and procedures.

- Arrays with electronic phase shifting or variable delay lines require new test equipments and procedures.

- Although MMW receives much attention as a test problem, examples of microwave tubes are still difficult to measure, especially if it has short pulse length (50 nanosecond) or high power in 100s of megawatts.

- GaAs FET monolithic IC has difficult- to- measure small milliwatt signals at 18-26 GHz. High frequency unique connector cable interface presents problems in hardware also.

- GaAs 4K Ram is unable to monitor the technology for high speed dynamic tests requiring 1 nanosecond access and gigahertz analog/digital sampling is not available.

- FLIR digital scan converter has low signal-to-noise and high speed parameters, which available spectrum analyzers cannot handle.

- Voice simulation needs a military standard for vocabulary, noise background, etc., to use in test and validation.

- Experimental tubes such as gyro clyston or gyro TWTs could present power and frequency test problems, but are not seen to be much different than production TWTs.

- Services reportedly do not have the capability to handle testing and repairing TWTs.

- TWT removal and return to factory for repair is a user field problem.

- Plasma high power beam presents challenging X-ray and frequency test equipment problems in a difficult high noise environment.

- The 35 GHz gyrotron will present some high power source difficulties. The combination of wideband and high power will always present test instrumentation and display problems.

- Microwave and MMW power is a greater test instrument difficulty than frequency. Extremely high power has always been a unique test measurement problem.

- Helmet mounted displays present unique test instrument challenges where gun barrel techniques like collimation bore-sight and scaling are combined with the human eye and optics sciences.

- Acousto-optics numerous problem measurement areas include wavelength spread, ampliture, output power and shape distortion. High speed optical processors will be in terahertz range.

- Fast array detection of visible wavelengths could be a test equipment problem during full scale production.

- Ultra high speed data processing GaAs ICs present a severe high speed monitoring test problem. Future random logic and memory programs will be hard to test at 1 nanosecond speeds or less.

- A potential test equipment measurement problem is in the area of very fast signal acquisition. Biomation s digital oscilloscope needs the capability of high speed signal averaging added. This may be only laboratory usable.

- Coherent optical correlator would present modulation alignment test problems when used with devices such as holographic filters.

- Testing of the optical modular crystal device itself tends to be complex and highly technical; for example, photon energy measurements, involving calculations, may be required.

- Laser frequencies have been difficult to field test, and this will magnify as frequencies of laser R&D proceed from nanosecond to femtosecond (10^{-15}) pulses.

- Magnetostatic wave (MSW) phase measurement maximum has increased 40 times over the 360° limited SAW devices; MSW delays to be measured are in nanoseconds.

- Radar frequency, spectrum and near field measurements are test shortfalls in existing microwave and future MMW radars.

- Although noted in regards to a digital microwave radar system, ECCM to simulate CW and pulse jammers with characteristics like frequency hop is needed for most new anti-jam electronics for realistic testing.

SECTION 3

SUMMARY OF IMPACT ON TEST TECHNOLOGY OF FUTURE TECHNOLOGIES

There were some responses indicating that the systems would utilize BIT and embedded computer diagnostics to avoid the need of special test equipment in the field, which was very encouraging. On the other hand, the many instances of specialized one-of-a-kind test equipment are disturbing. There are service "generic test equipment" policies and coordination programs such as MATE, CSS, ATSS and MCATE. The purpose and intent is to eliminate the proliferation of each "box" having its own unique "special test equipment." The follow-up contacts during this survey indicate that most of these R&D programs need to be made aware of the generic and field tester family policies relating to their programs.

Table 1 illustrates the crosssection of test and measurement tools currently in use by the R&D laboratories and contractors for the emerging technologies. Many of these test tools are sophisticated, specially designed and built, costly, sometimes large and require highly skilled engineers to use them. In many cases these test equipments are entirely unsuited to military use. Naturally, the goal is to test the equipment at the lowest level in the field, but use of some test equipment may be appropriate only at the intermediate level or production line. Nearly all of the laboratory R&D tools need to be made more rugged (militarized), more compact and usable by enlisted technicians, optimally in a field environment.

Measurements	Laboratory Tool
Timing	Stored Ion Spectroscope
Metal Strength	Differential Scanning Calorimetry Scanning Xmission Electron Microscopy Small Angle Neutron Scattering X-Ray Diffraction Scanning Photoacoustic Microscopy (SPAM)
Electro-Optic	White Light Interferometer Far IR Spectro Photometer Hologram
Laser	Doppler-Free Backward Fluorescence Spectroscopy
Molecular Optics	Polarized Raman Spectroscopy
NMMW	Hot Electron Mode Photoconduction Detector
Resonances	Singularity Expansion Method (SEM)
Optical Image	Pockel's Readout Optical Modulator
IR Detector	Heliostat Interferometer
Mechanical Stress	Over 13 tools identified utilizing Lasers, Ultrasonics, Holography, Gages, Photomicrography, Microscopes, SEM, etc.

Table 1. Emerging R&D test tools

SECTION 4

MATCHING POTENTIAL R&D TEST PROBLEMS WITH JLC PANEL ON AUTOMATIC TESTING (JLC-AT) SUBTASK DESCRIPTIONS

The emerging R&D technologies potential test problems from Appendix A are summarized in Section 2. How well does the most recent 30 November 1981 JLC Panel on AT meet these R&D tasks? Only the testing technology area subtasks need reviewing for match-up, since management and acquisition support do not directly support these test areas. The 30000 series MIS codes contain 50 test technology tasks under seven 31XXX to 37XXX subareas.

Many of the MIS codes were not applicable to the test problems noted in this survey and the 14 MIS codes which appear related in the matrix are listed in Table 2. The specific correlation (or lack of) to probable test problem R&D areas and existing JLC-AT test goals (subtasks) is shown in the matrix. Apparent test matches may not match due to restrictive subtask definitions. For example, some R&D task near field instrumentation may not be aided by MIS 30512, since it only applies to airborne antennas. The matrix reveals the following emerging R&D technologies which apparently are not addressed by the current JLC-AT testing technology MIS subtasks:

High power beams
Upper MMW
Superconductors
Voice simulation
Helmet displays
Acousto-optics
GaAs
A-O processing

NOTE: This report does not include individual service test technology programs in these areas.

MIS CODE	DESCRIPTION
30302	LSI/VLSI BIT Test Techniques
30502	Microprocessors
30503	Fiber-Optics
30504	Microwave Integrated Circuits
30505	Bubble and Mass Memories
30506	Charge Coupled Devices
30507	Electro-Optics
30509	Solid State Switching
30510	Pin Electronics
30511	Microwave ATE
30512	Near Field Antenna Measuring Technology
30704	Army Direct Support ATE
30705	Navy Family of ATE
30706	Air Force Family of ATE

Table 2. JLC Panel on AT testing technology MIS codes which could support R&D test problems.

The JLC Plan does not contain RDT&E tasks that benefit only one service. The Army, Navy and Air Force all have test technology plans not listed in the JLC because the application is unique to that service. No attempt was made to compare the test technology requirements with the plans of each individual service.

JLC-AT MATRIX CODING

"YES" indicates a match-up of JLC-AT code with the test problem area, no additional test technology should be required.

"X" under MIS code(s) indicates JLC-AT task is related and may solve a portion of the test problem.

"?" indicates too early in the program or an indefinite status to testing a query.

"None" column indicates no JLC-AT task for problem, although some MIS codes may be checked as a minor or related test impact area.

"Field ATE Family" right-hand 3 columns (30704, 30705, and 30706) indicate the field testers could possibly help, if so designed.

JLC-AT MATRIX

SYSTEMS TECHNOLOGY

		JLC TESTING TECHNOLOGY MIS CODE							
TECHNOLOGY	R&D TASK	30511	30502	30512	30504	NONE	30704	30705	30706
ECCM	Digital Microwave Radio System	X				?			
RADAR	Digital Beam Forming Radar - Lab					X			
	Ballistic Technology MMW Research					X			
	Terrain Following Radar					X			
	Electronically Agile Radar			YES	X				
	Antenna Systems Spatial Processing					X			
	Scanning Antenna Array Technology			X	X				
	Wing Array Radar Syst for VSTOL			X	X	?			
	Advanced Radar Technology		YES	X	X				

SYSTEMS TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE							
		30302	30502	30512	30504	NONE	30704	30705	30706
CONTROL	Control & Stabilization (Weapon Point)		YES				X		
	Surface Ship Concept Formulation	X				?		X	
	Low Cost RPV Technology				X				X
	Sea Ferret Mini-Unmanned Vehicle				X	?		X	
	Crack Growth Gage for Aircraft					X			
	Ultrasonic Method for A/C Structure					X			

COMPONENTS TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE							
		30504	30502	30505	30509	NONE	30704	30705	30706
SUPER-CONDUCT	Superconducting Electronics					X			
	Digital Squid E/M Receiver	?				X			
	Superconducting UHS A/D Convert					X			
	Superconducting Submicron Devices					X			
CRYOGENIC	Cryogenic Switching				?	X			
	Elect Cont Linear Helium Refrig					X			
	Ferroelectric Material MMW					X			
MMW	Near MMW Gyrotron					X			
	Gyrotron MMW					X			
	MMW Integrated Circuits					X			

COMPONENTS TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE							
		30504	30502	30505	30509	NONE	30704	30705	30706
	Monolithic ICs	X						X	
	43-45 GHz 250W TWT					?			X
VOICE SIM	VCID Test and Evaluation					X			
SCAN CONV	Common Module FLIR Digital Scan Convert	X	X			?			
NUKE GYRO	Cryogenic He3 Nuclear Gyro					X			
GAAS	GaAs FET Amplifier					X			
	GaAs 4K BIT Random Access Memory		YES						
	GaAs Gigabit Circuit Development					X			
	Monolithic SAW Structures					X			

COMPONENTS TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE								
		30506	30502	30504	30503	30510	NONE	30704	30705	30706
	Experimental Tubes					X	?		X	
	Magnetostatic Wave Propagation						X			
	Electro-Fluidic & Fluidic to Elect Convert					X				
	Optical and Acoustic Wave Research			X	X	X	?		X	
	Fluidic Rate Gyro Development						X			
	Quick Reaction Power Source						X			
	Monolithic Signal Conditioner			YES			?			
	CCD Implementation OF FFT	YES	X					X		
	High Speed Signal Processing	YES	X						X	

TRANSMISSION CM TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE						
		30504	30502	30302	NONE	30704	30705	30706
ENERGY BEAM	Exploratory Relativistic Beam Research				X			
	Free Electron Laser				X			
	Particle Beam Technology				X			
	Karl Initiation				X			
HIGH POWER	Adv Concept in High Power MMW Generat				X			
	MW & MMW Components	X					X	
	Peniotron Technology							
	High Power MMW Tubes				X			
	High Power Micro-Wave Tube Component				X			
	Gyrocon RF Amplifier Development				X			
	Circular Adaptive Arrays				?		X	
	Polarimetric Tech-nology Seeker			X	?	X		

ELECTRO-OPTIC TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE						
		30507	30504	30310	NONE	30704	30705	30706
MMW	Near Millimeterwave (NMMW) Radar Tech				X			
	Far IR & Submillimeter Electronics	X	X		?			
	NMMW Optically Pumped Sources				X			
	Hel Adverse Weather FC Acquis Radar				X			
	Detector/Mixer Elements				?	X		
	Research on Eigen Mode RF Generation			X	?			X
	IR Surveill Tgt Acquis Radar For Tank Locat	X	X		?			
LASER	Laser Radar Technology				X			
	Carbon Dioxide Laser Rangefinder				X			
	Modular Multifunction CW Laser Device				X			

ELECTRO-OPTIC TECHNOLOGY

		JLC TESTING TECHNOLOGY MIS CODE							
TECHNOLOGY	**R&D TASK**	**30503**	**30509**	**30302**	**30502**	**NONE**	**30704**	**30705**	**30706**
	Project TAU II Laser				X				
	Alpha I Design (DARPA)				X				
	Remote Detect of Bio Aerosol Clouds				X				
	Air Laser Lab Instru				X				
	Helmet Mounted Displays Simulation	X		X		?			
OPTIC PROCESS	Fresnel Lens/Beam Cont Optic Waveguides	X			X				
	Microchannel Optical Modulator	X			X				
	Integrated Optics	X			X		X		
	Phase Conjugate Optics	X			X				
	Integrated Optic Switch/Sig Process	X	YES		X		X		

ELECTRO-OPTIC TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE							
		30503	30509	30302	30502	NONE	30704	30705	30706
	Coherent Optical Correlator	?				X			
	IR Search and Track Technology					X			
	Holographic Lenses for Missile Guidance					X			
	Real-Time Airborne E-O Contrast Attenuate				X				
	Extending Useful EM Spectrum					X			

ACOUSTICS TECHNOLOGY

TECHNOLOGY	R&D TASK	JLC TESTING TECHNOLOGY MIS CODE						
		30502	30503	30302	NONE	30704	30705	30706
A-0	Miniature Acousto-Optic Spect Analyz	X	X	X				X
	Acousto-Optic Signal Processing	X	X	X		X		
	Optic Sound Generat and Amplification	X	X	X			X	
	Thin-Film Acousto-Optic Devices	X	X	X				X
	Holographic Optical Element	X	X	X				X
	Acousto-Optic Processing of 2D Signals	X	X	X				X

SECTION 5

RECOMMENDATIONS FOR NEW TECHNOLOGY RESEARCH

The R&D tasks judged to be potential test problems are summarized down to subgroups as shown in five main technologies as previously shown in Figure 1. Now that the possible testing shortfalls have been identified, corrective action is required to provide the test tools for any of these technologies that become operational systems.

Figure 2 depicts the R&D technological areas versus test challenges (i.e., particuliar instrumentation and measurement needs). Note that some items, such as "voice simulation," have one column "X" while others, such as "superconductor," have three columns "X's." This correlates to the number of probable test problems or R&D technology test difficulty.

The recommendations listed include the action required and the responsible service. The assignment of responsibility is based upon major users, research laboratories, or distribution of responsibilities. A few "big ticket" items, such as high energy beams, would require DoD wide funding. As noted in Table 1, some lab tools are in existence for some R&D technologies. In many cases instrumentation needs to be redesigned, ruggedized, simplified or reduced in size to be useful at field, repair or rework sites.

A breakdown of R&D test technology challenges and recommendations showing the primary service that should take action for developing the needed testing capability, follow:

A. **TEST ECCM** Although test capability for ECCM features for C^3 such as frequency hop and other anti-jam techniques is essential for all services, the Army is recommended for the action responsibility. Enemy counter-fire based upon intercepted communications is a constant threat to the Army.

B. **RADAR** Measurement problems in radar vary with beam shape, near field, power, sidelobes and beamforming arrays all being identified in traditional microwave frequencies. Millimeter wave (MMW) and upper bands present further needs for new on-line instruments and techniques. Due to the number and variety of radar types in its inventory the Navy should lead this effort.

C. **SUPERCONDUCTORS** A great deal of research is being conducted by Navy activities. The extremely low temperature and signal levels present tough test challenges, as well as high nanosecond switching speed and magnetic fields. Due to the high cost and broad application of this area, it is recommended that DoD pool resources in this R&D area.

D. **CRYOGENICS** Being related closely with superconductors, this science also applies to laser cooling and the space environment. This technology is also recommended for DoD responsibility rather than one service. Cryogenics and superconductors both appear to be "bit ticket" items.

	TEST CHALLENGE					
R&D TECHNOLOGY	HI SPEED	SMALL SIGNAL	HI POWER	HI FREQ	DELAY SHIFT	NEW TECHNIQUE
TEST ECCM	X			X		
RADAR				X	X	X
SUPERCONDUCTORS	X	X		X		
CRYOGENICS	X					X
MMW			X	X		
VOICE SIMULATION						X
DIGITAL SCAN CONVERTER	X	X				
NUCLEAR GYRO		X				
GaAs DEVICES	X	X		X		
MAGNETOSTATIC WAVE	X				X	
HIGH ENERGY BEAM			X	X		
HIGH POWER			X			
GYROTRON			X	X		
PARTICLE BEAM			X	X		
GYROCON			X	X		
LASER			X	X		
HELMET DISPLAY						X
OPTIC PROCESSING	X				X	X
IR STARTLE				X		
BIOLOGICAL DETECT		X		X		
ACOUSTO-OPTICS	X	X				X
A-O SIGNAL PROCESS	X				X	X

Table 3. Breakdown of R&D technology test problems into generic measurement and instrumentation needs

E. **MILLIMETER WAVE (MMW)** Use of Near MMW (NMMW) and MMW are increasing in fielded systems. Many R&D projects in this area show promise of operational usefulness. The Navy is doing considerable research in this area and it should be the action service for developing measurement tools.

F. **VOICE SIMULATION** This technology has a large commercial application, so civilian vendors will probably provide much equipment as a fallout from the open market competition. The military has a unique word and noise environment, and the Air Force is recommended for action in this due to the potential heavy avionic application.

G. **DIGITAL SCAN CONVERTER** This type of device is used in various service applications ranging from sonar to avionics. The small signal and high speed present challenging problems to test. The Army is recommended for action on this task.

H. **NUCLEAR GYRO** This was one R&D area where a difference of opinion existed between contacts as to whether a future test problem exists. The quantum increase in accuracy gained would seem to present measurement and calibration difficulties. The Air Force should determine if a test and calibration problem exists and take it for action if in fact new instruments are needed.

I. **GaAs DEVICES** The GHz rate and nanosecond access timing present measurement obstacles in these ICs. The Navy is proposed as the lead service. Several civilian contractors and vendors are working in this technology, so there may be existing test expertise available to use.

J. **MAGNETOSTATIC WAVE (MSW)** The Air Force is nominated as the lead service for developing test equipment for MSW. The measurement of thousands of degrees of phase shift relates to large fixed array radars which is a major Air Force function.

K. **HIGH ENERGY BEAM** Several R&D programs surveyed fall into this category such as Free Electron Laser (FEL) and Electron Beam Accelerators. All are very large, fixed, preliminary laboratory devices. Due to the complexity and high cost of these experiments, it is proposed that the DoD fund development of test and measurement tools in this area.

L. **HIGH POWER** Many R&D fields involve using familiar devices while greatly increasing the power levels. All across the electromagnetic spectrum, higher power is an R&D goal. Rather than special test devices for each program, a portable generic high power tester could be of great value to many projects and fielded systems in the future. Due to multi-service application and probable high cost, this type of tester is recommended as a DoD project, although services could possibly assist in many ways.

M. **GYROCON** The Soviet Union has developed this technology to convert DC to high power RF. The Air Force is modeling this device and should be the primary action service on this R&D testing of high power.

N. **LASER** Laser technology presents a broad R&D field with numerous potential applications; and this variety presents a unique set of test problems. To make this manageable, it is proposed that R&D laser test problems be broken into power levels and service responsibilities assigned accordingly. The Air Force would be the action service for high power testing due to space applications, the Navy for medium power lasers and the Army for lower level designation and IFF laser test instruments.

O. **HELMET DISPLAY** This R&D area was initially developed and then dropped by the Air Force. The Army is deeply involved in application of helmet displays and should serve as the focal point for this technology.

P. **OPTIC PROCESSING** The devices and techniques of optic processing are being reduced in size and increased in speed. The Air Force is doing major development work and test instrumentation should be handled by that service.

Q. **INFRARED (IR) STARTLE** Since this is an anti-tank project, the Army is the logical choice to develop IR test solutions for the field.

R. **BIOLOGICAL ATTACK DETECTION** The Army is recommended to be responsible for developing IR and UV field test instruments since the biological division at Aberdeen is already doing much work.

S. **ACOUSTO-OPTICS (A-O)** New devices involving holographic principles work at tetraherz speeds and with small signals. The Air Force is recommended to develop test techniques due to its involvement.

T. **A-O SIGNAL PROCESSING** Although there is overlap between A-O devices and processing, the overall architecture and end-to-end testing is proposed as a Navy task, with the Navy work in processing for various threats including ASW.

MAINTENANCE MANAGEMENT RECOMMENDATIONS

A. Traveling Wave Tubes (TWT) are returned to the factory for test and repair. The Navy should take action and try to develop and/or acquire TWT test and repair capability.

B. The DoD, via the JLC, should respond to the need for R&D activities to learn the military programs consolidating testers. This should reduce the flood of special purpose, unique ATE for similar technologies and encourage generic ATE.

C. The DoD should promulgate a policy or guidelines for the lowest possible maintenance level for ATE use. Exception and justification for depot or lab ATE should be documented and approved.

D. The JLC should provide a data feedback loop to ensure that the JLC panel on AT MIS codes more closely match. The emerging R&D AT needs as identified in the JLC-AT in Section 4.

FOLLOW-UP ACTIONS

APPENDIX A

ASSESSMENT OF RDT&E EFFORTS

FOR

TESTING IMPACT

ON

EMERGING TECHNOLOGIES

NOTE: The following comments are conversations with designated parties and not necessarily opinions of the Tri-Service Test Technology Group.

APPENDIX A INDEX

SYSTEMS TECHNOLOGY

NOTE: *Probable Test Problems

NOTE: *Probable Test Problems

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NOTE: *Probable Test Problems

SYSTEMS TECHNOLOGY

TITLE: DIGITAL MICROWAVE RADIO SYSTEM, RDT&E CATEGORY 6.2

OBJECTIVE: To provide a replacement radio for the AN/GRC-144 Radio in the 1990 time frame, that will operate in an ECM environment.

APPROACH: This contractor will perform a study and analysis of appropriate ECCM techniques, design a system implementing these techniques and write a technical specification for the resultant system. The techniques include steerable null antenna system, spread spectrum and frequency hopping modems and error correction codes. Also, the contractor will analyze three on-going technique contracts (in the above ECCM technique areas) and recommend an optimum integration of these techniques. All this will be done for tactical DMR contractor amended 17 Sept 81 to do this for strategic application of the LOS Digital Microwave radio also, as well as tactical application. This will include a reconsitution capability and will include modularity of functional designs so as to provide only the degree of AJ protection required for the tactical/strategic application.

PROGRESS: The preliminary design concept has been completed, and is being finalized.

FOLLOW-UP ACTION

ORGANIZATION: Signatron Inc, Lexington, MA 02173

POINT OF CONTACT: Monsen, Peter, Dr. **TELEPHONE:** (617) 861-1500

SUMMARY OF DISCUSSION: This radio will be very sophisticated and have many ECCM features such as frequency hopping. In the field, many of the ECCM features degrade undetected. Present test equipment is too specialized, complex, and costly. The need is for simple, generic ECCM field test sets.

CONCLUSION AND RECOMMENDATIONS: Calibrated noise sources with frequency hop capability is required to check out ECCM circuits by simulating pulse jamming. This ECCM low cost tester will be increasingly needed for more Tri-Service equipments and commonality will be very cost-effective.

TITLE: DIGITAL BEAMFORMING RADAR, RDT&E CATEGORY 6.1

OBJECTIVE: The objective of this investigation is to design, build and test a linear array which forms beams in a digital computer, rather than in a microwave feed. The emphasis on the effort is to relate component errors in the array to antenna performance, and to examine multiple beamforming capability and flexibility.

APPROACH: An eight-element array will be built with a receiver behind each element to down convert the signal from RF through IF, and finally to a digital representation. The component errors, including such factors as mutual coupling, phase and amplitude mismatch, will be carefully characterized. Pattern tests are to be taken and the performance compared to that obtained from theoretical analysis. Following the pattern tests, the antenna will be integrated in a prototype radar and target detection tests performed.

PROGRESS: Antenna array and associated receive equipment built and components tested. Pattern tests begun and error analysis approximately 1/2 complete.

FOLLOW-UP ACTION

ORGANIZATION: MICOM Army Missile Lab, Redstone Arsenal, AL 35809

POINT OF CONTACT: Loomis, J.M., Dr. **TELEPHONE:** (205) 876-1707

SUMMARY OF DISCUSSION: Because it involves an array of antennas, we need a scheme to verify that all elements are matched up. There is a need tc be able to provide a signal from a remote source to the array for test and calibration of same. Low side lobe antennas which involve critical manufacturing tolerances are tested, working and have not been degraded. In the field there is no way to know that. Very fine measurements are required, some work has been done by Navy in this area. They hope in future to develop and field millimeter aperture systems, e.g., very small antennas. This may require a whole family of newly developed state-of-the-art test equipment.

CONCLUSION AND RECOMMENDATIONS: The need for a remote signal source for radar and fine tolerence measurements are legitimate field needs that are very broad in application. The new MMW radars do present a requirement for new technology test equipment and this is a Tri-Service need for nearly all platforms.

TITLE: BALLISTICS TECHNOLOGY, MILLIMETER WAVE RESEARCH
RDT&E CATEGORY 6.2

OBJECTIVE: To demonstrate the feasibility of a 140 GHz beam rider radar and 217 GHz beam rider radar in the anti-tank anti-aircraft role for the 140 GHz radar and in the anti-tank role for the 217 GHz radar.

APPROACH: For the 140 GHz beam rider to check beam wander in tracking, the target acquisition and signal processing problem and the missile capture problem. To develop better components in terms of higher power and more sensitivity. Investigate the beam rider versus aircraft and to measure backscatter from rain and attenuation by rain, haze and fog. For the 217 GHz to assemble the beam rider configuration and to begin field tests.

PROGRESS: 78 09-79 05. The 140 GHz tracker upgrade has been designed and the required parts are in order. The 217 GHz radar is operational and the first task of collecting propagation data is under way. Contracts were let to develop a phase-coherent source and a quasi-optical power combiner at 217 GHz. 79 05-80 05. The 140 GHz tracker is operational and is being calibrated for tracking tests and signal processing. The 217 GHz propagation tests are complete and the equipment is being converted to a tracker (conical scan) for multipath tests. The 217 GHz source contract is proceeding on schedule. Critical components for the 140 GHz monopulse have been ordered (extended interaction oscillator, antenna comparator and modulator). 8005-8102. The four-frequency propagation station has been completed and was put to immediate use in the snow-one exercise. The E10 modulator contract was awarded to Westinghouse. The 217 GHz source contract has been completed. 8102-8202. The four-frequency propagation station was used in the snow-one and snow-one a exercises successfully during February-March 81 and January-February 82. The E10 modulator contract was successfully completed. The 140 monopulse antenna was delivered and a contract for the monopulse RF network was awarded to Alpha Industries.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM Ballistic Model Div, Aberdeen PG, MD 21005

POINT OF CONTACT: McGee, Richard A **TELEPHONE:** (301) 278-6672

SUMMARY OF DISCUSSION: Calibrated receivers for field testing are needed to measure frequency content and spectral content. Little off-the-shelf instrumentation is available. According to Mr. McGee, the development of test instrumentation would probably be as difficult or more difficult than development of primary equipment using this developing technology.

CONCLUSION AND RECOMMENDATIONS: Mr. McGee's insight to the difficulty in developing test instrumentation is far too uncommon. The MMW frequency and spectrum measurement needs are very important to all Tri-Service systems using MMW, which is to be very widespread in application.

TITLE: LPI TERRAIN FOLLOWING RADAR DEMONSTRATION RDT&E CATEGORY 6.3

OBJECTIVE: This acquisition is for an advanced development demonstration of low probability of intercept terrain following radar techniques. This capability will enhance penetrating A/C survivability through a substantial reduction in energy radiation from the aircraft. The basic terrain following concept is a demonstrated part of current operational systems such as the F-111, B-52, A-6 and RF-4C. The electronically agile radar (EAR) program has recently demonstrated a significantly enhanced terrain following sensor capability in the presence of rain, ECM, towers and sloping terrain. The Low Probability of Intercept Radar (LPIR) program has recently shown the value of Low Intercept Probability (LIP) techniques for air/air radar modes. This program will extend the results of the LPIR program to the terrain following capabilities demonstrated in EAR to provide a substantial reduction in A/C observability.

APPROACH: This advanced development effort will design and implement Low Probability of Intercept (LPI) techniques using existing radar equipment. The modified radar will be extensively tested on the ground to establish the performance of the system. A flight demonstration of the techniques performance will be conducted system. A parallel task in this acquisition is the study, simulation, grid referenced stored terrain data base. The capabilities to be developed are an essential element in the development of future strike radar systems such as are planned for the development in the COVIN REST (covert, in weather RECCE strike) concept.

PROGRESS: 820104-820401. The contract was awarded with a February start date. Work started on 15 February 1982 and currently is in the analysis and study phase.

FOLLOW-UP ACTION

ORGANIZATION: Avionics Laboratory, Radar Branch, Wright-Patterson AFB, OH 45433

POINT OF CONTACT: Deberry, David R. **TELEPHONE:** (513) 255-4516

SUMMARY OF DISCUSSION: This program is in too early a stage to indicate potential test problems. Most radars have similar characteristics so nothing unique is anticipated at this date for test requirements.

CONCLUSION AND RECOMMENDATIONS: It is possibly over simplification to state that all radars are the same. Other follow-ups have stated test shortfalls for microwave radars instrumentation.

TITLE: ELECTRONICALLY AGILE RADAR, RDT&E CATEGORY 6.3

OBJECTIVE: To define, design, fabricate and test a preproduction prototype multifunction radar whose performance, physical characteristics, reliability, maintainability, nuclear hardness and cost are consistent with and meet the current and projected air-to-ground and air-to-air needs of strategic weapon systems.

APPROACH: Phase I of the overall EAR development program is a 70 month development effort to provide a balanced design, fabricate a minimum of two Service Test Models (STM) and perform ground and flight tests to lend credibility to attain the performance, cost, reliability, maintainability and nuclear hardness goals. EAR will be designed to operate with the B-1, FB-111 and B-52 weapon systems; however, only the necessary interface with a particular weapon system will be accomplished to provide flight test evaluation. Technical performance goals are not fixed and will be iterated prior to CDR to be consistent with life cycle costs and reliability goals.

PROGRESS: 790221-801201. The flight tests were completed in December 1979. Draft copies of test reports and final report are in review. The tower testing has been extended until June 1982 to determine some key factors in the terrain following failsafe implementation.

FOLLOW-UP ACTION

ORGANIZATION: Avionics Lab, Radar Branch, Wright-Patterson AFB, OH 454333

POINT OF CONTACT: Deberry, David **TELEPHONE:** (513) 255-4516

SUMMARY OF DISCUSSION: Fielded hardware would probably employ BIT to isolate failures to Line Replaceable Units (LRUs). These would be taken to depot for testing an existing radar test stations. A "near field antenna tester" would be a valuable addition to have in the field.

CONCLUSION AND RECOMMENDATIONS: Although microwave radars and test equipment have been in the field for decades, it is interesting that a shortfall such as a near field antenna tester, still comes to light. This could be a general, Tri-Service test problem in an "older" technology.

TITLE: ANTENNA SYSTEMS SPATIAL PROCESSING, RDT&E CATEGORY 6.1

OBJECTIVE: Originate, develop and/or evaluate new antennas, spatial processing techniques and measurement procedures to help solve Navy antenna systems needs, such as improved target resolution or suppression of jamming.

APPROACH: Theoretical analysis and computer simulation of the promising new ideas, algorithms and techniques to investigate their performance characteristics. When feasible, laboratory models are fabricated and tested to obtain experimental evaluation.

PROGRESS: Eigen-analysis techniques, coupled with appropriate modeling and antenna aperture spatial averaging, are theoretically capable of providing asymptotically unbiased estimates of the number of signals present, directions of arrival, relative strengths, and coherence. They have been applied to multiple source situations which include mixtures of coherent and non-coherent sources of unequal strengths, and the simulations stimulate optimistic implications regarding the simultaneous accurate tracking of closely space multiple sources/targets.

FOLLOW-UP ACTION

ORGANIZATION: NRL Radar Division, Code 5372, Washington, DC 20375

POINT OF CONTACT: Gabriel, W. F., Dr. TELEPHONE: (202) 767-2584

SUMMARY OF DISCUSSION: Dr. Gabriel anticipated the use of BIT and on-line testing with its own computer for testing. Digital antenna testing would be required, but due to the pecularities of the complex system, a special system tester with electromagnetic, aperture and digital features is needed. A tailored tester architecture was seen to be needed.

CONCLUSION AND RECOMMENDATIONS: Although the BIT and on-line testing were encouraging, the special tailored tester just continues the old program of a different tester for each gray box in the field. This cannot be afforded and a more generic approach common to different radars is called for.

TITLE: WING ARRAY RADAR SYSTEMS FOR V/STOL, RDT&E CATEGORY 6.3

OBJECTIVE: Develop radar technology, concepts, requirements and components to meet the 1990 and future threat. Efforts are directly applicable to such efforts as V/STOL A, E2-C updates and

VAWX. Platforms require radars which are highly reliable and maximize the common subsystems between AEW and ASW variants. Feasibility demonstration of new techniques such as solid transmitters, phased arrays and antenna pattern are needed to achieve these requirements.

APPROACH: Work under this task will consist of (1) developing hardware techniques for a flyable solid state conformal radar, (2) integrating the new hardware into a radar system, (3) developing software for system signal and processing and system control, and (4) evaluating the system performance on top test site. The results of this effort will be a feasibility demonstrating the solid state conformal radar system concept as embodied in this approach, i.e., system parametric data for use by airframes.

PROGRESS: June 1980 - December 1980 the procurement package for the flyable state conformal radar was prepared. Support has been provided to the P conformal radar effort, and Phase I module testing has been completed.

FOLLOW-UP ACTION

ORGANIZATION: Naval Air Systems Command, Washington, D.C.

POINT OF CONTACT: King, Bill **TELEPHONE:** (202) 692-7415

SUMMARY OF DISCUSSION: This technique (wing array) is a long way from implementation and its likelihood is slim. For present efforts, normal radar calibrated receivers and processors are sufficient for measurements where checking of individual deploys is involved. Further field tests of deployed systems might be very involved, requiring special test equipment.

CONCLUSION AND RECOMMENDATIONS: The conformal radar arrays may necessitate special field instrumentation, unless the test philosophy of "a radar is a radar" regardless of antenna shape, were to apply.

TITLE: ADVANCED RADAR TECHNOLOGY (LIGHTWEIGHT INTEGRATED MMW SENSOR), RDT&E CATEGORY 6.2

OBJECTIVE: 8101-8201. The LIMS project was a new start in FY81 and the results were phased into the follow-on advanced radar technology program which is a combined LIMS/AFCOR radar technology effort. The LIMS Low Probability of Intercept (LPI) waveform generation hardware and computer-interface control software have been completed. A high speed digital convolver for extended range target detection was designed and fabrication initiated. The convolver and waveform generation hardware will be integrated with a 94 GHz radar transceiver frontend and tested during FY82 under the advanced radar technology program.

APPROACH: The approach will involve integrating the ARRADCOM fire control laboratory's Programmable Signal Processor (PSP) with an experimental coherent solid-state 94 GHz transceiver having a 1 GHz instantaneous bandwidth. The modulation will be a combination of frequency hop, interrupted-CW and bi-phase code. The waveform will be designed to have good range resolution and utilize a high duty cycle (high average power) for extended range detection compatable with the peak-power limitations of MMW solid-state sources. The performance of the LPI sensor will be enhanced by PSP-controlled RF power management techniques.

PROGRESS: This project is a new start in FY81. However, the results of the PSP program (FY79 and FY80) are applicable. In the PSP program, the MMW transceiver design and the LPI signal processing was studied. A procurement was initiated for a state-of-the-art coherent, wide band, solid-state 94 GHz transceiver in FY80. This present effort as outlined in the approach will include the procurement of approximately $102K in hardware for the LIMS.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM, F.C. Division, Dover, NJ 07801

POINT OF CONTACT: Coleman, N. **TELEPHONE:** (201) 328-5828

SUMMARY OF DISCUSSION: Test equipment seems adequate within the limitations of hardware interface and data reduction. The mass of off-line data needs to be replaced by real-time testing for faster and more useful test results.

CONCLUSION AND RECOMMENDATIONS: This large mass of off-line data, which requires time-consuming and costly massaging to result in useful test information, is probably a common R&D lab problem. Either this test technique must be replaced by compact, on-line testing or the testing will not be performed outside of the R&D lab environment.

TITLE: CONTROL AND STABILIZATION (PRECISION WEAPON POINTING) RDT&E CATEGORY 6.2

OBJECTIVE: Develop advanced design concepts based on modern control and estimation theory for precision weapon/sight control and stabilization in a dynamic fire-on-the-move environment.

APPROACH: Advanced feedforward control concepts and optimal feedback regulator concepts will be applied to the problem of precision weapon pointing in the presence of linear and nonlinear disturbance inputs. Concepts will be simulated to evaluate performance in the presence of disturbances and nonlinear plant characteristics.

PROGRESS: 8101-8201. A prototype microprocessor based digital stabilization system has been developed and tested on AN XM97 helicopter turret system. Modern control theory and advanced disturbance accommodation techniques were used to synthesize the control law for stabilizing the turret in the presence of recoil and base motion disturbances. An 8086 based microprocessor with a high speed mathematics board was used for the control law implementation. A more advanced controller has recently been developed using Intel 8087 high speed microprocessor chip which is capable of implementing higher performance control laws. Testing of this improved system began in JAN 82. Four technical papers were published.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM, F.C. Division, Dover, NJ 07801

POINT OF CONTACT: Coleman, N. **TELEPHONE:** (201) 328-5828

SUMMARY OF DISCUSSION: The lack of real-time test technique and data reduction is a problem in this microprocessor based digital stabilization system. Some special analyzers are becoming available recently. Hughes is one source of data analysis equipment. Use at a remote site is very difficult. Smaller and battery powered data analysis equipment are needed.

CONCLUSION AND RECOMMENDATIONS: This is the kind of area response that was very field- and user-oriented in its thrust, even to battery power source. This data reduction is a Tri-Service general equipment test need.

TITLE: SURFACE SHIP CONTINUING CONCEPT FORMULATION, COMBAT SYSTEM SUPPORT, RDT&E CATEGORY 6.3

OBJECTIVE: Provide combat system concepts for the platforms being considered in the surface ship conform effort.

APPROACH: The approach is to generate, in two parallel efforts, the combat system performance characteristics and a base of engineering data related to current and future combat subsystems and their impact on the plantform. Combat system concepts are generated by selecting a group of subsystems that collectively satisfy the performance characteristics. The impact of these systems on the platform, in terms of weight, volume and utility requirements is then determined. The concept is then assessed and modified as required to meet the capability of the platform with appropriate performance changes noted.

PROGRESS: During FY81 basic data bases and correlations of shipboard weapon and combat system characteristics were completed and initial correlations made. Combat suites were synthesized for a Navy combatant, a corvette hydrofoil and a battle group escort.

FOLLOW-UP ACTION

ORGANIZATION: Naval Sea Systems Command, Ship Design, Washington, D.C. 20362

POINT OF CONTACT: Lawson, Chuck **TELEPHONE:** (202) 692-7296

SUMMARY OF DISCUSSION: The combat systems concepts being dealt with are over 20 years away and test planning is not being considered at this point. The DDG-51 program was proposed as a likely candidate for testing queries.

FOLLOW-UP ACTION

POINT OF CONTACT: Gregorits, Robert **TELEPHONE:** (202) 692-7243

SUMMARY OF DISCUSSION: The DDG-51 is a 1990s timeframe project. It has some BIT, monitoring and diagnostics, and is mostly software oriented. Mr. Gregorits was not aware, at his program level, of test problems at this time.

CONCLUSION AND RECOMMENDATIONS: It seems that organizations responsible for large combinations of equipments, such as Packet Communications or ships, are at too high a level to handle test queries. Each equipment manager can handle these adequately. This may point out the lack of test sensitivity at the high integrated system level, which was the aim of ORMs ove. a decade ago.

TITLE: LOW COST RPV TECHNOLOGY DEMONSTRATION (AVIONICS)
RDT&E CATEGORY 6.2

OBJECTIVE: The Air Force function of this effort is to investigate low-cost unmanned alternatives for target strike, ECM and defense suppression missions. Current manned and unmanned systems for these missions are very high cost and include risk to human life. An opportunity exists for substantial cost savings and increased mission effectivenss by developing expendable mini-drones for these missions. The objective of this effort is to develop low-cost avionics systems including autopilots and flight

controls for expendable mini-drones. This development contributes directly to the flight demonstration of mission capabilities of mini-drones which will provide strategists and tacticians with low-cost, low-risk alternatives to current systems.

APPROACH: The contractor will design, fabricate, test and develop autopilots, flight control systems and other avionics subsystems compatible with mini-drones and mini-drone payloads for target detection, target track and ECM. The avionic systems developed will be integrated with GFE mission payloads into project flight test vehicles for flight demonstration of operational concepts. Special emphasis will be given to cost minimization during design and fabrication efforts and low-cost off-the-shelf components will be used to the maximum extent practicable.

PROGRESS: 811111-820520. Preparation of XBQM-106 tail number 11 for the electric RPV program took place NOV 81 through JAN 82. The flight control and data systems which were installed worked well during testing, but the test vehicle crashed prior to completing the program. The vehicle is being repaired and the same avionics test systems will be reinstalled for additional testing at Eglin AFB in late JUN 82. Fabrication of the low cost digital autopilot hardware is nearly complete. Flight testing in XBQM-106 tail number 17 is tentatively scheduled for JUN 82. The autopilot development program has been sponsored by FIGL since 1 APR 82, and will continue after the FIMS/MINI-RPV group disbands in JUL 82.

FOLLOW-UP ACTION

ORGANIZATION: Aeronautical Systems Division, Wright-Patterson, AFB, OH 45433

POINT OF CONTACT: Jorgeson, David **TELEPHONE:** (513) 255-4450

SUMMARY OF DISCUSSION: The mini-RPV have GO/NO GO launch testing, If they fail, they go to depot, similar to Navy torpedoes. The depot would have special test equipment for the RPV. No field test or maintenance is planned.

CONCLUSION AND RECOMMENDATIONS: If the RPV is regarded as ordnance in its LCC support, it would not be a nominee for field test instrumentation.

TITLE: SEA FERRET MINI-UNMANNED VEHICLE (UMV)
RDT&E CATEGORY 6.3

OBJECTIVE: To provide technical support to NAVSEA 62R5 in the areas of mini-UMV design, payload, launcher system design and communication link design; also, to provide mission analysis, payload tradeoffs, system

scenarios studies, and to plan, coordinate, arrange and support an at-sea prototype mini-UMV demonstration. Provide program initiation support in FY83 and technical/contract support through full scale development (FY84-88).

APPROACH: Mission analysis and mission effectiveness analysis on the overall potential of the expendable mini-UMV will be conducted. The analysis will determine the tactical, technical and cost effectiveness of employing mini-UMV in the surface warfare area. Payload/mission selection, candidate mini-UMV payloads will be evaluated upon mission suitability, payload availability, shipboard integration requirements, technical compatibility with the mini-UMV and compatibility with the communications link. At-sea prototype demonstration plan, coordinate and arrange all necessary fleet and range support to accomplish an at-specification, RFP and award contract. Full scale development, contract monitoring technical and test support for design review, flyoff, TECHEVAL and OPEVAL.

PROGRESS: Monitored Boeing UMV demonstration program, preliminary data link investigation and strawman specification complete, prepared the following, preliminary mission analysis summary, initial payload summary at sea-demo test plan and procedures, appraisal of Marine Corps ROC, fact shees for ASN and Op-35. Tri-Service RPV applications summary for Newag report, first draft or the briefings for the five flag level presentations. An ERPV program plan has been formulated and reviewd by OP-35, NSEA-62R5 and NSEA-62W.

FOLLOW-UP ACTION

ORGANIZATION: Naval Sea Systems Command, Washington, D.C. 20361

POINT OF CONTACT: Lubin, B. **TELEPHONE:** (202) 692-1684

SUMMARY OF DISCUSSION: The Sea Ferret mini-unmanned vehicle is a remote controlled bomb, expendable and treated like ammunition. Possible test needs could include the telemetry functions, and a recoverable RPV for training and test of associated equipment in test flights.

CONCLUSION AND RECOMMENDATIONS: It is interesting that this contact thought of some field test possibilities even for this one-shot ordnance RPV. It is possible that a generic RPV Tri-Service tester could be needed in the future.

TITLE: EVALUATION OF A CRACK GROWTH GAGE AS AN INDIVIDUAL AIRCRAFT TRACKING CONCEPT, RDT&E CATEGORY 6.2

OBJECTIVE: This work effort supports the requirements of force management for individual aircraft tracking as specified in Tasks IV and V of MIL-STD-1530A, "Aircraft Structural Integrity Program, Airplane Requirements" and associated military specifications. The Air Force function for this effort is to study advanced Individual Aircraft Tracking (IAT) concepts. However, the data acquisition techniques for predicting potential crack growth in critical areas of fighter/attack/trainer and bomber/transport aircraft have not been adequately developed. This has resulted in high life cycle costs and inaccurate adjustment of inspection and repair intervals of Air Force operational aircraft. The objective of this program is to determine the feasibility of a crack growth gage for satisfying force management individual aircraft tracking requirements. This program will provide the capability to more accurately predict potential damage in critical aircraft structure, improve the planning and scheduling of structural maintenance actions and reduce life cycle cost of USAF weapon systems.

APPROACH: This program will include (1) sensitivity analysis studies on the crack growth gage, (2) development of transfer functions, (3) methods of attachment investigations (adhesives, bolt-on techniques), (4) design, fabrication, testing, evaluation (including effects of retardation) and verification of the crack growth gage and (5) studies of data recording and processing methods.

PROGRESS: 801114-810625. Preliminary testing is under way in two areas, gage geometry evaluation (the effects of gage dimensions on stress) and retardation studies (testing a side-groove concept under constant delta K conditions). The T-38 will be the baseline aircraft for this effort. Stress history tapes are being evaluated.

FOLLOW-UP ACTION

ORGANIZATION: Flight Dynamics Lab, Structural, Wright-Patterson AFB, OH 454333

POINT OF CONTACT: Wilkinson, Rodney, LT **TELEPHONE:** (513) 255-6104

SUMMARY OF DISCUSSION: The crack growth gage for aircraft structure was under verification testing, but recently lost funding temporarily. If successful it will move to 6.3 category. It is a unique design concept.

CONCLUSION AND RECOMMENDATIONS: The JLC testing committee has concentrated on electronic testing, but material testing has become an increasing need, especially for aircraft. There is increasing awareness of crack testing for ships and vehicles also, for Tri-Service interest.

TITLE: EXPLORE ULTRASONIC METHOD FOR AIRCRAFT STRUCTURE, RDT&E CATEGORY 6.1

OBJECTIVE: Analyze and develop innovative ultrasonic data processing and display techniques. Provide consulting services in the field of Non-Destructive Evaluation (NDE) for aircraft structures.

APPROACH: The capabilities of a recently developed data acquisition system will be augmented in the areas of data display and analysis. Display improvements will center principally on software development. Data analysis schemes will be more fundamental, centering on calculations of the required data density and reduction of raw data to enhance images. Experimental approaches will include the use of materials under development, such as composites, and bonded structural systems.

PROGRESS: Pattern recognition algorithms have been successfully demonstrated. Small microstructural differences, generated through electron beam weldment of a titanium alloy, have been well classified and delineated using NRL's data acquisition system. A report describing the augmented NDI capabilities using such technology is nearly complete.

FOLLOW-UP ACTION

ORGANIZATION: Naval Air Systems Command, Washington, D.C. 20361

POINT OF CONTACT: Schmidt, Dick **TELEPHONE:** (202) 692-7444

SUMMARY OF DISCUSSION: NASC is developing this technology using lab equipment; NAEC, Lakehurst is developing actual equipment. A new approach using ultrasonics is being developed. Presently a small hand-held crystal ultrasonic device is being used to scan structures. This method is considered inadequate and automated equipment is needed to properly do the job. This research is looking into pulsed laser holography which creates a sound wave excitation of the structure which is detected with a laser using holographic techniques. This technique can focus and look internally to detect subsurface flaws in laminated, composite materials. As the prime equipment is developed, there may be a need to develop special test equipment along with it.

CONCLUSION AND RECOMMENDATIONS: This appears to be a next-generation to the hand-held ultrasonic field testers. As the testing becomes automated and larger in scope, it too will need test equipment for itself. This is an emerging fact to many new technologies such as robotics and ATE.

COMPONENTS TECHNOLOGY

TITLE: SUPERCONDUCTING ELECTRONICS, RDT&E CATEGORY 6.1

OBJECTIVE: To explore the unique properties of superconductors in the development of electronic systems that will have improved performance compared to competing normal state electronics. Current emphasis is on the study of the physical principles behind the operation of devices based on the Josephson effect and on evaluating the feasibility of using these devices in surveillance and communication systems.

APPROACH: Various configurations of Josephson effect devices will be fabricated from refractory, high superconducting transition temperature films and their response to electronmagnetic radiation studies as a function of the frequency of the incident radiation, the device geometry, operating temperature, excitation (pump) frequency and electronic detection system. Emphasis will be placed on understanding those physical processes which may limit the low noise performance and restrict the high temperature operation of these devices.

PROGRESS: The fabrication has begun of all NBN Josephson tunnel devices with sputtered amorphous silicon barriers. Detailed experiments have been undertaken to vary the deposition parameters for the counter-electrode to maximize superconducting transition temperature while minimizing substrate temperature, so that earlier prepared portions of the device will not be degraded during counter-electrode deposition. A study of the effects of alpha particle irradiation on the behavior of Josephson devices has been stated.

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research NRL, Washington, D.C. 20375

POINT OF CONTACT: Nisenoff, M., Dr. **TELEPHONE:** (202) 767-3099

SUMMARY OF DISCUSSION: NRL is devising test, evaluation and calibration procedures for the superconductors. The superconductors present a different set of problems. The discussion led to the low cryogenic temperatures and the fact that infrared detectors also used the closed cycle cryogenic refrigeration. The next generation devices would need to instrument for 10^{0} kelvin.

CONCLUSION AND RECOMMENDATIONS: Josephson junction superconductors and cryogenics are two high priority test problem nominees for JLC consideration.

TITLE: TOTALLY DIGITAL SQUID E/M RECEIVER CONCEPTS, RDT&E CATEGORY 6.2

OBJECTIVE: This work seeks new approaches to provide a totally digital, burn-out-proof, SQUID-based, electromagnetic receiver for Navy communication, radar and EW systems.

APPROACH: A superconducting quantum interference device (SQUID) will be used to detect and quantize electromagnetic signals. Other SQUIDs will be used to count the quantized units per unit of the time and thus form A/D converters requiring no preamplification of the E/M signal.

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research (Code 414), Navy Dept., Arlington, VA 22217

POINT OF CONTACT: Berlincourt, Ted, Dr. **TELEPHONE:** (202) 696-4212

SUMMARY OF DISCUSSION: The superconducting quantum interference device (SQUID) has the Josephson junction test problems of low signal level and low temperature, but it can be a radar or communications detector and used in computer applications. It is a different circuit configuration.

CONCLUSION AND RECOMMENDATIONS: Superconductor cryogenics and low level signal detection will require new state-of-the-art instrumentation for test by all services.

TITLE: WEAPONRY: SUPERCONDUCTIVE ULTRA-HIGH-SPEED ANALOG-TO-DIGITAL CONVERTER, RDT&E CATEGORY 6.3

OBJECTIVE: This work seeks to develop superconductive A/D converters with sampling rates in excess of 10 GHz for signal processing of complex microwave signals in weaponry and ECM systems of the Navy.

APPROACH: Comparative studies of two concepts (in-line junction and 2-or 3- junction SQUIDs designs) will be performed. Transmission line simulations will be undertaken to assess the attenuation and dispersion of microstriplines at frequencies near the energy gap and to determine the effects of stripline crossovers and impedence mismatching. Detailed analysis of converter speed limitations versus level of accuracy will be developed. The properties of Josephson junctions and transmission lines will be determined for a variety of fabrication techniques. Circuit testing and demonstration of an 8 bit A/D converter is planned by the end of FY 82.

PROGRESS: Josephson junctions have been designed, fabricated and successfully tested. Stability after repeated cycles to room temperature has been achieved. A 6-bit 2 GHz JJ A/D converter has been successfully built and tested. Josephson junction A/D converter development May 1979 to May 1980, dated June 80.

FOLLOW-UP ACTION

ORGANIZATION: National Bureau of Standards (Cryogenic), Boulder, CO 80302

POINT OF CONTACT: Hamilton, Clark **TELEPHONE:** (303) 497-3740

SUMMARY OF DISCUSSION: This Josephson junction AD converter handles data at too high a rate to measure; 24 gigabit/second is the maximum handled to date. Tricks and imagination are required to test in the laboratory.

CONCLUSION AND RECOMMENDATIONS: In addition to the extremely low signal level and temperature of Josephson junctions, the 24 gigabit data rate makes this AD converter a monumental test instrument challenge.

TITLE: SUPERCONDUCTING SUBMICRON DEVICES, RDT&E CATEGORY 6.1

OBJECTIVE: This contract is studying the electronic properties of submicron size superconducting tunnel junctions of direct interest to the Navy for surveillance, communication and signal processing. Those specific properties required for practical, optimum and reliable operation are being studies in detail.

APPROACH: Submicron size superconducting tunnel junctions containing tunneling barriers made of various oxide and composite materials are being prepared and various electronic properties will be studied. The properties, limitations and digital applications of superconducting micro-tunnel junctions are being investigated.

PROGRESS: A new reactive ion beam oxidation technique has been developed for the fabrication of oxide barrier Josephson tunnel junctions. This technique has yielded NB NBO (X)-PBBI tunnel junctions of very high reliability and excellent characteristics. Record critical current densities (10(6) AMPS/CM(2)) have been obtained. A new edge junction technique has been developed to produce junctions of very small area and high impedance. Junction areas of 3x10 (-100CM(2)) have been achieved with no deleterious effect on junction characteristics. Preliminary 55 GHz mixer experiments with these junctions have yielded mixer performance unequalled by any non-superconductor mixer. A new material, NB-AL alloy, has been developed as a refractory resistor material for Josephson

integrated circuit technology. Fabrication of small metallic particles for very low temperature studies is in progress. (High quality submicron niobium tunnel junctions with reactive ion beam oxidation, A.W. Kleinsasser and R.A. Buhrman, applied physics letters 32 (November 1980).)

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research (Code 414), Arlington, VA 22217

POINT OF CONTACT: Berlincourt, Ted, Dr. **TELEPHONE:** (202) 696-4212

SUMMARY OF DISCUSSION: These superconducting submicron devices operate at liquid helium temperatures (around 4 kelvin) and at 55 GHz test rate. The magnetic environment is critical and voltage levels are much lower than silicon. Totally new test equipment is required for all of these reasons.

CONCLUSION AND RECOMMENDATIONS: Another example of the unique test challenges of Josephson junctions with high speed, low signal levels and temperature, plus magnetic factors. A Joint Service very tough test problem.

TITLE: CRYOGENIC SWITCHING, RDT&E CATEGORY 6.2

OBJECTIVE: This work seeks to better understand, to model and to develop semiconductor devices which operate at 77K for use on extremely high speed signal processing devices contemplated for future Navy E/M systems.

APPROACH: GaAs FETs will be designed, fabricated, characterized and optimized for use at 77°K. Speed-powerproduct, fan-out and logic potential will be addressed. NOR gates and ring oscillators will be fabricated in monolithic form.

PROGRESS: A technique has been developed to purify the GaAs substrates used for this work. Epitaxial layers doped in the 1015/CM3 to 1016/CM3 region have been reliably reproduced. Good ohmic contacts to this low-doped material have been made, but reproducibility remains a challenge.

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research (Code 427), Arlington, VA 22217

POINT OF CONTACT: Berlincourt, Ted G. **TELEPHONE:** (202) 696-4212

SUMMARY OF DISCUSSION: Semiconductor devices that operate at 77° Kelvin temperature have the high speed and cryogenic measurement test problems, but the voltage levels are similar to silicon chips and present no voltage measurement difficulty.

CONCLUSION AND RECOMMENDATIONS: These cryogenic switches share the superconductor instrumentation problems, with the exception of voltage level. JLC action on superconductors will cover these devices as well.

TITLE: ELECTRONIC CONTROLLED LINEAR HELIUM REFRIGERATOR, RDT&E CATEGORY 6.2

OBJECTIVE: To assess the feasibility of using linear energy extraction devices and electronically controlled values to optimize the refrigeration cycle of a helium expansion engine from 300 degree K to 4.2 degree K.

APPROACH: Configure a helium expansion engine and collect baseline data for optimum operation over the temperature range. These data will be used to program a microprocessor for automatic control of the refrigeration process through cooldown to liquid helium production. The results of this effort will be incorporated into a shipboard helium liquifier.

PROGRESS: (8202-8210) Tests are continuing with expansion engine and electronic controls in lower temperature regimes to improve efficiency. Microprocessor is being hard wired to the expansion engine controls. Initial automatic control algorithms have been written. Effort is underway to integrate these algorithms with the laboratory software package contained in the microprocessor.

FOLLOW-UP ACTION

ORGANIZATION: David W. Taylor NSRDC (Propulsion and Auxiliary)
Annapolis, MD 21402

POINT OF CONTACT: Green, Geoffrey **TELEPHONE:** (301) 267-3632

SUMMARY OF DISCUSSION: Work on the helium expansion engine concept is aimed at shipboard use and test has not been considered yet. Design redundancy and automated test at the depot were probable approaches. Commercial silicon diode devices are used in measurements. Two cryogenic instrumentation problem areas, in addition to temperature, are flow at 300°K to 4.2K and pressure measurement. Strain gages are brittle and silcon diodes are fragile at such low temperatures.

CONCLUSION AND RECOMMENDATIONS: The 4 to 300 degree kelvin flow and pressure measurements require new test approaches. More rugged silicon diodes and pressure transducers to replace strain gages, are proposed areas of possible solution to tests.

TITLE: NEAR MM GYROTRON, RDT&E CATEGORY 6.1

OBJECTIVE: To design and fabricate a gyrotron that will produce near millimeter (T-/MM) radiation with power - 5 KW.

APPROACH: Contractor will design electron gun in detail and supply NRL with drawings from which the gun can be fabricated. A subsequent contract will be let for gun fabrication. Gyrotron cavity will be designed for maximum efficiency using existing computer code. Gun and cavity will be combined with low average power beam collector and NA output window for initial tests of peak power capability, efficiency and coherence.

PROGRESS: Initial tests of the gyrotron have been performed. Approximately 1000 W at 120 GHz and 100 W at 240 GHz have been obtained.

FOLLOW-UP ACTION

ORGANIZATION: Naval Research Lab (Plasma Physics) Code 4740, Washington, D.C. 20375

POINT OF CONTACT: Read, M., Dr. TELEPHONE: (202) 767-4004

SUMMARY OF DISCUSSION: The gyrotron looks like a microwave tube and will replace a TWT. Using large, laboratory type test equipment on 35 and 94 GHz. Department of Energy and Army Image Radar are working on 120 GHz and 240 GHz MMW, respectively, and these frequencies present tougher HF test problems.

CONCLUSION AND RECOMMENDATIONS: Another few examples of MMW measuring problems requiring JLC support and development. Both Army and Navy labs are involved in this particular R&D task.

TITLE: GYROTRON MILLIMETER WAVES, RDT&E CATEGORY 6.1

OBJECTIVE: The Navy needs millimeter wideband amplifiers for communications, radar and ECM. From current studies and understanding there is excellent potential for developing gyrotron traveling-wave-amplifiers with power and efficiency comparable to the existing gyrotron oscillators, and also with instantaneous bandwidth in the range of 2-10 percent adequate for perceived radar and communications systems requirements.

APPROACH: Pursue a fundamental understanding of the physics underlying the gyrotron millimeter wave generator and amplifier in all of its aspects. Experimental, theoretical and computational studies will be carried out on irregular electromagnetic structures, cyclotron harmonic interactions, nonlinear self-consistent electron beam coupling and frequency injection for phase locking and stabilization. Improved understanding resulting from these studies will allow advanced development and production of gyrotron devices at millimeter wavelengths with high power, bandwidth and efficiency.

PROGRESS: A gryrotron tube has been constructed. The tube has been operated in the oscillator mode to test the electron gun performance. The electron gun has operated at 40 KV and 5 AMPS approximately 10 KW of microwave power for an efficiency of 5 percent. The frequency is 6 GHz. An interaction tube with a dielectric blanket has been constructed for the slow wave gyrotron amplifier experiment.

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research (412), Arlington, VA 22217

POINT OF CONTACT: Condell, W.J. **TELEPHONE:** (202) 696-4220

SUMMARY OF DISCUSSION: The gyrotron traveling wave amplifier (TWA) is the same high frequency MMW measurement challenge as any other gyroton, but additionally has higher voltage (40 KV) and power (10 KW) test parameters.

CONCLUSION AND RECOMMENDATIONS: Same basic MMW problem of the gyrotron with higher voltage and current testing.

TITLE: VCID TEST AND EVALUATION, RDT&E CATEGORY 6.23

OBJECTIVE: Workload requirements levied on active aircrew members are increasing at a rapidly accelerating pace. Because of high task demands, technologies are being actively sought that will enable the pilot to manage this workload, while allowing him to keep his head out of the cockpit, i.e., not required to monitor indicator lights or instruments, turn dials or knobs. This technology search, coupled with the recent advances in and industrial applications of automatic speech recognition (ASR) technology, has led to numerous proposals for incorporating ASR into the cockpit as a means of providing the pilot a hand-eye free data input capability. At the present time General Dynamics, as well as the French and British Air Forces, is planning to flight test ASR devices in high performance aircraft. General Dynamics is intending to test a device built to military specifications on the AFTI-16 during flight tests

scheduled for March-December 1982. AFAMRL, in cooperation with the AFTI-ADPO, AFWAL/FIG, General Dynamics and their subcontractors, is providing technical, scientific and financial support to this evaluation under the Voice Control Input Device (VCID) program.

APPROACH: The AFAMRL input to this program consists of partial funding of the flight test portion of the program, and also the generation of a data base of voice changes occurring under acceleration, noise and vibration stresses in order to provide for ground testing of the device and tuning of the recognition algorithm before it is flown. AFAMRL personnel also provide technical support to the program in the area of audio instrumentation.

PROGRESS: 810828-820401. During the current reporting period a data base has been collected of voice outputs under conditions of (1) acceleration, (2) vibration and (3) simulated cockpit noise environment. In addition in-flight recordings of voice and environmental noise have been collected during low level, high speech flight in a F-16. This data base has been used by General Dynamics, Lear-Siegler and ITT to help in the development of a flight-worthy Voice Control Input Device (VCID) to be flown on the AFTI-16. In addition AFAMRL personnel have provided consultation services to flight dynamics lab, General Dynamics and Lear-Siegler in the areas of psycho and physical acoustics and audio recording. Semiannual review was accomplished 30 March 1982 in conjunction with the preparation of the TMR.

FOLLOW-UP ACTION

ORGANIZATION: 6570 Aerospace Med Rsch Lab (BIONICS), Wright-Patterson AFB, OH 45433

POINT OF CONTACT: Anderson, Tim **TELEPHONE:** (513) 255-3660

SUMMARY OF DISCUSSION: Voice simulation is difficult to test. Validation of claimed accuracy of speech words recognized is needed. How to test is debated, such as live or taped words. Each manufacturer has a different vocabulary and use their own voice criteria. In March of 1982, an NBS conference considered developing a standard.

CONCLUSION AND RECOMMENDATIONS: Even if the NBS did come out with a speech simulation standard, it would not be adequate for the military environment, such as noise background and so forth. The JLC needs a military voice simulation standard for test purposes.

TITLE: COMMON MODULE FLIR DIGITAL SCAN CONVERTER, RDT&E CATEGORY 6.3

OBJECTIVE: The objective is to develop a common module digital scan converter (DSC) for Forward Looking Infra Red (FLIR) thermal imaging systems. The DSC provides the interface between the FLIR sensor and the system display(s) which require standard video output. The DSC is the key to implementation of automatic/autonomous functions into host weapon systems utilizing FLIR data. The DSC provides the interface between the FLIR sensor and the peripheral automation equipment(s) requiring digital signal processing.

APPROACH: The approach is to develop a family of DSC modular components to meet the functional and configurational requirements for implementation into both existing and future host systems. The DSC will be functionally designed as three sets of core modules. These modules consist of a Scan Position Sensor (SPS), Signal Conditioner Multiplexer (SCM) and Reformatter (REF). The SCM and REF are further partitioned into subsets expandable by 60 channel increments to minimize system on-gimbal configuration and to optimize functionality of signal processing features. These include underlayed, 10 BIT digital output, automatic responsivity and level equalization, automatic gain control, dynamic range compression (e.g., the "chow" concept of automatic low frequency gain limiting), frame freeze, frame integration, electronic zoom and line interpolation.

PROGRESS: 8007-8201. Delivery of the brassboard has slipped and is projected for the end of second quarter FY82 with integration and flight demonstration in fourth quarter FY82.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Night Vision & E-O Labs, Ft Belvoir, VA 22060

POINT OF CONTACT: Kessler, H. M. **TELEPHONE:** (703) 664-1551

SUMMARY OF DISCUSSION: The scan converter modules present test problems of 20 megabit high speed digital information and a low signal-to-noise ratio. Spectrum analyzers are presently being used but they are unsatisfactory and inadequate for the task. Mr. Kessler asked to be contacted in a year when he would have a better handle on test needs.

CONCLUSION AND RECOMMENDATIONS: Modular scan converters can be used on various equipments from sonars to aircraft GCA, and a next generation spectrum analyzer is needed for these and other low signal R&D devices.

TITLE: CRYOGENIC HE3 NUCLEAR GYRO, RDT&E CATEGORY 6.1

OBJECTIVE: AF function - self contained high precision navigation systems are of prime military importance in air and space flight and weapons systems. Opportunity-results in atomic physics and cryogenic technology suggest the use of particle spins as gyroscopic reference with a potential for very high accuracy guidance systems realizations at reduced costs. Objective-demonstrate the feasibility and the limitations of a cryogenic nuclear magnetic resonance gyroscope as precision angle and angular rate reference, followed by an assessment of the potential of its combination with a cryogenic gravity-gradiometer. How work contributes will lead to a new guidance system which employs local vertical tracking and complements or improves conventional inertial guidance systems.

APPROACH: Polarized HE3 nuclei, cooled to 4.2 K, will be caused to precess at right angles to a small constant magnetic field and the precessing signal observed. Use is made of experience already obtained in techniques for polarizing HE3 by optical pumping, obtaining long nuclear relaxation times, obtaining very low homogeneous and stable magnetic fields inside superconducting shields, fabricating and testing quartz gyro housings and using SQUID magnetometry for gyro readout. The first part of the effort will concentrate on construction and testing of the instrument, which is to render data for its evaulation as a candidate for an all-cryogenic inertial measuring unit, together with cryogenic gradity gradiometers and accelerometers already under development under AFLSR sponsorship.

PROGRESS: 790601-800630. Nuclear magnetic relaxation times have been measured on liquid hydrogen coated walls. Times measured are long and consistent with limitations imposed by magnetic field gradients and stability in the low precision apparatus used. This gives confidence that much longer times will be achieved in the high precision, spherically symetric apparatus when it is ready. Substantial progress has been made in excluding magnetic fields from inside lead superconducting shields. Fields less than 10^{-7} have been achieved and less than 10^{-8} are expected with the present metholodogy.

FOLLOW-UP ACTION

ORGANIZATION: AF Office of Science Research, Solid State, Bolling AFB, Washington, D.C. 20332

POINT OF CONTACT: Feldman, Dr. **TELEPHONE:** (202) 767-4906

SUMMARY OF DISCUSSION: The nuclear gyro is many times more accurate than today's gyros, and this product "advantage" becomes a test instrument problem requiring more sensitive test equipment. Dr. Feldman suggested that he be contacted again a few years from now for better test information for nuclear gyros.

CONCLUSION AND RECOMMENDATIONS: Whether nuclear, cryogenic or whatever, future gyros will certainly require a new generation of gyro test equipment due to increased accuracy. One person talked to did feel that "a gyro is a gyro" and they would not be more difficult to test.

TITLE: GAAS FET AMPL (HUGHES), RDT&E CATEGORY 6.2

OBJECTIVE: The goal of this program is to develop, during a period of 24 months, a small signal, gallium arsenide field effect transistor amplifier which operates over the frequency range 18.0 GHz to 26.5 GHz, has a minimum gain of 40 DS, a maximum noise figure of 10 DB and a minimum power output of 5 milliwatts.

APPROACH: The first year of this effort will be directed toward the development of the necessary devices and prototype amplifiers. The second year's activity will be focused upon the development of the multistage amplifiers with integral but replaceable power supplies which are in a configuration suitable for TWT replacement.

PROGRESS: An eight-stage amplifier having 35-40 dB gain over the 18-26.5 GHz band has been developed and delivered to NRL. The noise figure of this amplifier ranged between 11 and 13 dB over 90 percent of the band. This amplifier was capable of delivery at least 75 MW of power across the band.

FOLLOW-UP ACTION

ORGANIZATION: NRL Electronics Technology Division, Code 6811, Washington, D.C. 20375

POINT OF CONTACT: Sleger, K.J., Dr. **TELEPHONE:** (202) 767-3894

SUMMARY OF DISCUSSION: The GaAs FET is intended to be a monolithic device to be discarded if bad. The small milliwatt signals at 18 to 26 GHz need IEEE-488 boxes with a computer for noise figure testing. The ICs would need internal diagnostics. The interface hook-up and cables are a serious problem.

CONCLUSION AND RECOMMENDATIONS: If MIL-STD requirements for BIT and diagnostics are not enforced for ICs, the field test problems will be overly burdensome. Testability cannot be "added on later" to ICs. The high speed and low signal levels make portable field ATE use nearly impossible.

TITLE: GAAS 4 K BIT RANDOM ACSS MEMORY RDT&E CATEGORY 6.2

OBJECTIVE: The goal of this program is the development and demonstration of a monolithic 4-Kbit, 1-Nsec GaAs RAM (Random Access Memory) for use in advanced high-speed signal processing systems operating at gigabit/sec data rates. The design of this memory will be based on the results of an investigation into GaAs memory design and fabrication issues conducted under previous NRL contracts.

APPROACH: The first year effort will center on the fabrication and evaluation of a 64 bit random access memory test chip. Functional DC characteristics of this memory and peripheral circuits will be determined. Emphasis will be placed on control and uniformity of device parameters and chip yield. Preparation will be made for high-speed measurements to be performed in a follow-on effort.

PROGRESS: The program has been redirected to focus on a self-aligned gate technology for ENFET memories. To this end, a new mask set has been designed and process run will begin shortly, multi-funded, work units and sponsors are: 0794 100,000 0848-01 107,000; total to date: 207,000.

FOLLOW-UP ACTION

ORGANIZATION: NRL Electronics Tech Div, Code 6811, Washington, D.C. 20375

POINT OF CONTACT: Sleger, K.J., Dr. **TELEPHONE:** (202) 767-3894

SUMMARY OF DISCUSSION: The manufacturer checks DC functions of the GaAs RAMs. High speed dynamic testing at 1 to 2 GHz rate and 1 nanosecond access time is impossible. Analog signals are at one gigabit/second and digital at 2 GHz rate.

CONCLUSION AND RECOMMENDATIONS: The GHz and nanosecond testing of ICs dynamically problem should not necessarily fall on the ATE designer's shoulders. The IC should have testability designed in to have accessible data with minimal interface difficulty. The JLC needs to have an enforceable IC testing and design policy or MIL-STD.

TITLE: EXPERIMENTAL TUBES, RDT&E CATEGORY 6.2

OBJECTIVE: To provide various types of traveling wave tubes for the AN/SLQ-32 extended capabilities developments and the Tri-Service K-band brassboard EW system.

APPROACH: To procure traveling wave tubes in accordance with the specifications as set forth in the attached task assignment.

PROGRESS: New Problem - Not Applicable.

FOLLOW-UP ACTION

ORGANIZATION: NRL Electronics Tech Div, Code 6843, Washington, D.C. 20375

POINT OF CONTACT: Zutkoff, A. **TELEPHONE:** (202) 767-3114

SUMMARY OF DISCUSSION: The R&D task called for buying production TWTs for use by Raytheon in updating the SLQ-32 EW system. Although not in Mr. Zutkoff's area, he noted that gyro clyston and gyro TWTs could possibly pose testing difficulties.

CONCLUSION AND RECOMMENDATIONS: R&D tasks or points of contact for investigation of possible gyro clyston or TWT test problems were not in the follow-up documentation.

TITLE: MAGNETOSTATIC WAVE (MSW) DEVICES FOR SIGNAL PROCESSING, RDT&E CATEGORY 6.1

OBJECTIVE: Improved microwave signal processing components are essential to improve Air Force microwave communications, countermeasures and reconnaissance systems. The present microwave solid state signal processing devices operate on the surface acoustic wave principle and can barely reach 1 GHz for many applications. Components are needed which can process higher frequencies without the need of down-conversion to 1 GHz or lower. An opportunity exists to develop a higher frequency processing technology by using magnetostatic waves in ferromagnetic YTTRIUM iron garnet (YIG). The objective of this effort is to develop a novel microwave (1-20 GHz) signal processing technology based on magnetostatic waves propagating in YIG based materials. A specific objective is to demonstrate the promise of the new technology by fabricating and testing magnetostatic surface and volume wave transversal filters, 2-port resonators, resonator filters and electronically variable time delay components. This effort will advance microwave analog signal processing by making available a technology which can perform many functions needed in advanced reconnaissance, surveillance, communications and electromagnetic warfare systems at far lower cost and weight and with far higher speed and reliability than current technology allows.

APPROACH: The University of Texas at Arlington has proposed many innovative device design approaches to construct magnetostatic wave (MSW) devices analogous to surface acoustic wave (SAW) devices. Their MSW

devices would have the additional features that would (1) permit operation at much higher frequencies, (2) allow wideband tunability just by varying a magnetic bias field and (3) achieve very attractive passbands. MSW technology starts with thin epitaxial films of YIG on a substrate of non-magnetic material (GGG). Arrays of thin film wire loop antennas are used as ports into the MSW medium. The investigators have some unique ideas for posts which couple energy strongly into the material while making a minimum of stray MSW radiation. The propagation speed of the MSWs can be varied by changing the IAS magnetic field in which the YIG film is immersed, allowing frequency and time delay tunability. The path of the MSWs can be accessed to permit construction of transversal filters. The investigators propose to continue their investigation of this technology by refining their model of a three-port transducer and two-port resonator, investigating temperature compensation using thermally engineered magnets and building and characterizing their innovative device designs.

PROGRESS: 810701-820401. During the past year, the University of Texas investigators have derived a full three-port s-parameter transducer model, which includes evanescent modes and metal loading as well as the MSSW (magnetostatic surface wave) effects, measured the

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FOLLOW-UP ACTION

ORGANIZATION: Rome Air Development Center Hanscomb AFB, MA

POINT OF CONTACT: Setharis, Jim **TELEPHONE:** (617) 861-4663

SUMMARY OF DISCUSSION: Current Surface Acoustic Wave (SAW) devices are limited to under 1 GHz and microsecond delays. Magnetostatic Wave (MSW) is 1-20 GHz and in nanosecond delays. Current phase measurement devices have a maximum 360° range, but MSW must measure phase of a few degrees with a maximum of tens of thousands of degrees range. This phase accuracy over a long time delay requires a new type of test equipment.

CONCLUSION AND RECOMMENDATIONS: If MSW were used on a phased array steered beam radar, it would require a portable field tester for phase accuracy measurements from 1-20 GHz with nanosecond delays. All three services would have utilization of such a tester.

TITLE: ELECTRO-FLUIDIC AND FLUIDIC-ELECTRO CONVERTERS, RDT&E CATEGORY 6.1

OBJECTIVE: The objective is to perform research on effective methods for converting low level electrical signals into fluidic (pneumatic) signals and for converting low-level pressure (fluidic) signals to higher-level (power) pneumatic pressures.

APPROACH: Piezoelectric bender characteristics will be investigated regarding sensitivities to environmental stresses. Various configurations using piezo-benders with the HDL fluidic Laminar Proportional Amplifier (LPA) will be investigated to achieve optimum electro-fluidic conversion. Low-cost fluidic-to-pneumatic power amplifier design will be determined through analytical and experimental effort.

PROGRESS: None Reported.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Harry Diamond Laboratories, Adelphi, MD 20783

POINT OF CONTACT: Manion, F.M. **TELEPHONE:** (202) 394-3080

SUMMARY OF DISCUSSION: The electro-fluidic converter is in full commercial production and use. It also is a temperature sensor and not sensitive to radiation. This converter is ideal for test and monitor interface functions.

CONCLUSION AND RECOMMENDATIONS: This was investigated to see if applicable for sensing analog functions for ATE or performance monitoring needs. It seems to offer a useful function for these areas and is available off-the-shelf.

TITLE: OPTICAL AND ACOUSTIC WAVE RESEARCH - JSEP, RDT&E CATEGORY 6.1

OBJECTIVE: To provide the Navy with the technological basis for improved solid state electronic components and devices for communications, surveillance, navigation and information handling by taking advantage of vast expertise available at institutions of recognized standing such as this one under the Joint Services Electronics Program (JSEP). The study of optical and acoustic waves in solids and their interaction with external fields leads to advanced delay lines, acoustic imaging devices, signal processors and acoustic rotation sensors.

APPROACH: The subject emphasis at Stanford Ginzton laboratory is acoustic microwaves and optics. Projects include measurement of fast physical processes using picosecond laser pulses, optical fiber

communication systems and couplers, studies of the electrical behavior of superconducting quantum devices using high TC materials, acoustic storage devices, nonlinear interactions of acoustic waves with domains in ferrous materials and laser surface mass spectroscopy.

PROGRESS: The first truly satisfactory refractory metal superconducting microbridge has been fabricated. All the associated deposition and lithographic technology has been developed for this NB/AU/NB link device. A direct fiber-to-fiber single mode directional coupler has been developed. It has mechanically variable coupling and low throughput loss. A VUV narrowband light source has been developed by using anti-stokes radiation from a HE discharge irradiated by light from a tunable, visible pump laser. (Annual progress report, Ginzton Lab Report No. 3126, April 1980, under contract N00014-75-C-0632, Stanford University.)

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research, Arlington, VA 22217

POINT OF CONTACT: Berlincourt, Ted, Dr. **TELEPHONE:** (202) 696-4212

SUMMARY OF DISCUSSION: This is very basic research work and no specific instrumentation area was cited as a problem area. However, optical systems used in communications gear and sensors for sensing acoustic fields, etc., might well require new specialties in military personnel training and new equipments for testing and maintenance. A lot of fiber optics work is being performed by Ted Schimitzeck at NOSC. Also a lot of such research is being performed at NRL.

CONCLUSION AND RECOMMENDATIONS: This is another example of broad and multi-faceted programs and high level lack of specific test correlation.

TITLE: FLUIDIC RATE GYRO DEVELOPMENT, RDT&E CATEGORY 6.2

OBJECTIVE: The objectives are to design, develop, build and bench test environmentally qualified fluidic rate sensing circuits that can replace conventional rate gyroscopes in missile autopilot and short-term navigation systems.

APPROACH: The fluidic Laminar Jet Angular Rate Sensor (LJARS) will be the heart of the fluidic rate gyro. Also to be included will be an electrically-driven pneumatic power supply and a suitable output pressure transducer to provide an electrical output signal. A total of five fluidic rate gyros are to be fabricated in this project.

PROGRESS: None reported.

FOLLOW-UP ACTION

ORGANIZATION: Garrett Corporation, Phoeniz, AZ 85034

POINT OF CONTACT: Tippetts, Tom TELEPHONE: (602) 231-3969

SUMMARY OF DISCUSSION: Fluidic rate gyros lack on-line test capability. Angular rate tables and record tables should facilitate testing. Automated testing of 100/day is needed for production line testing.

CONCLUSION AND RECOMMENDATIONS: Fluidic Laminar Jet Angular Rate Sensors (LJARS) need on-line ATE and rate tables to enable production or field testing. Various platforms could use the LJARS.

TITLE: QUICK REACT POWEP SOURCE (DAOY0039), RDT&E CATEGORY 6.2

OBJECTIVE: To design a power source system that is initiated during missile launch and capable of providing design steady state voltage within 250 milliseconds of initiation.

APPROACH: Two systems concepts will be explored to determine feasibility. The first approach is to use a turboalternator to provide the electrical power, with the turboalternator itself being driven by a stored cold gas that is initiated upon missile launch. The second approach consists of a battery with its electrolyte separately stored. The electrolyte is injected into the battery cell stack at launch. Mathematical simulations of the dynamics of both systems will be conducted to determine expected system performances as well as specific system limitations. Promising hardware concepts will be pursued to the point of procuring and testing prototype units.

PROGRESS: Computer simulations were conducted to determine the dynamic response of each system concept. Initial results indicated that the turboalternator system offered the best possibility of meeting the start up time requirement at a relatively low development risk. The high electrolyte velocities during transfer impose large hydraulic loads on the battery system and offers the possibility of damaging the battery cell stack. To support the analysis of the turboalternator system a computer program for the analysis of real gas effects at ultra-high pressure was implemented. This program was developed by the Navy and is reported in NWC-TP-6252. Two contractual efforts are planned for this effort; the first is for the design, demonstration and fabrication of four prototype turboalternator systems; the second is for the design demonstration of the battery system concept and for a parametric study of battery design parameters and system response. Both efforts are scheduled to begin in 4QFY82/1QFY83.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM Nuke and Fuse Div, Dover, NJ 07801

POINT OF CONTACT: Franz, A. H. **TELEPHONE:** (201) 328-5405

SUMMARY OF DISCUSSION: The turboalternator with cold gas is no problem to test. The batteries are one shot with no test prior to fire. Electro chemical test equipment is unavailable.

CONCLUSION AND RECOMMENDATIONS: With the increased use of critical quick reaction batteries for missiles and smart weapons JLC way need for electro chemcial testers.

TITLE: MONOLITHIC SIGNAL CONDITIONER, RDT&E CATEGORY 6.2

OBJECTIVE: The objective of this effort is to develop a broadband amplifier that can be connected by external passive components to form microwave low noise amplifiers, mixers, filters RF amplifiers on a single substrate. The basic substrate will operate from 30 MHz to L-band. This will form the basic building for a universal receiver for radars. It will allow 1 to 2 orders of magnitude size and weight reduction over current technology and an order of magnitude reduction in cost.

APPROACH: The signal conditioner will be designed and built using Monolithic Microwave Integrated Circuits (MMIC) using silicon on sapphire. The first task will be a thorough study of radar receivers and the functional design for the signal conditioner. This will be followed by detail design and fabrication (processing) of the MMIC signal conditioner.

PROGRESS: 811028-820525. Candidate silicon on sapphire field effect transistor devices have been designed and fabricated for use on this program. The devices have been characterized and perform to the required 2 gigahertz frequency. The design of the 'kernel' circuit is complete. Analysis of this circuit using 'COMPACT' indicates that the circuit will perform satisfactorily over the required bandwidth. Additional devices are being fabricated to increase gain over the bandwidth. Using the candidate circuit and the field effect transistor presently in hand, a hybrid breadboard of the active transformer was constructed. Tests indicate a problem with biasing that was not revealed by COMPACT and ameliorative measures are being incorporated in the design. Preliminary study of active filter design has been initiated and preliminary designs will be validated with COMPACT in the near future.

FOLLOW-UP ACTION

ORGANIZATION: Rome Air Development Center, Griffiss AFB, NY 13441

POINT OF CONTACT: Polniaszek, Joseph J. **TELEPHONE:** (315) 330-4381

SUMMARY OF DISCUSSION: Monolithic microwave chips are tested like an amplifier using a Hewlett-Packard CW network analyzer. A pulse network analyzer would be better to use. A complete Transmit-Receive (TR) module will be more difficult to test. Rack-and-stack IEEE-488 equiment could test TR modules. If it becomes LSI, faults could be isolated similar to microprocessor. Still working on the design.

CONCLUSION AND RECOMMENDATIONS: Another example of test concern for a chip, possibly with LSI, with a new design of a pulse network analyzer proposed. BIT and self test would seem the optimum testability approach for microwave ICs. JLC guidance must be provided vendors.

TITLE: CHARGE COUPLED IMPLEMENTATION OF DIGITAL FAST FOURIER TRANSFORMS 15801-EL, RDT&E CATEGORY 6.1

OBJECTIVE: To study the possible implementation of modular functional blocks that perform digital fast Fourier transforms using charge transfer techniques. Relevance, small high-density, low-power fast Fourier transform devices are essential to many Army applications in image, radar and communication signal processing.

APPROACH: To study logic design, layout, performance and power consumption and design modular circuits which can be utilized for implementation of fast Fourier transforms with binary charge coupled logic circuitry. Modules such as radix -2, -4, and -16 and the cordic vector rotator will be studied and models will be built and evaluated. Topology will be considered and computer modeling will be used in the design. Parallel-pipelined and serial approaches will be studied.

PROGRESS: 8006-8106. Eight designs have been proposed for the computation of an N element Fourier transform. The largest of the designs requires O (N2LOG N) units of silicon area and operates in O (LOG N) time. The smallest designs occupy only O (N LOG N) area, but take O (N LOG N) time to perform their calculations. The designs exhibit an area-time tradeoff: the smaller ones are slower, for two reasons. First, they may have fewer functional units and thus less parallelism. Second, their functional units may be interconnected in a pattern that is less efficient but more compact.

FOLLOW-UP ACTION

ORGANIZATION: DARCOM Army Research Office, Durham, NC 27709

POINT OF CONTACT: Suttle, J.R. **TELEPHONE:** (919) 549-0641

SUMMARY OF DISCUSSION: Measurements on modules are being made in the lab. These are still general concepts and not systems. Suttle can't "crystal ball" test needs 15 years from now. High speed FFT processing is involved but Dr. Suttle couldn't say how fast. In his opinion, we cannot avoid future test problems with the approach of following-up on 6.1 to 6.3 category R&D tasks. This project was just terminated.

CONCLUSION AND RECOMMENDATIONS: This was the most outspoken critic of this JLC emerging technology approach, although less overt skepticism and difficulty in anticipating future test needs were noted among a few other parties contacted. Hopefully the JLC will prove these doubters wrong by funding development of new ATE capable of allowing operational test of these new technologies 10 years from now.

TRANSMISSION ELECTROMAGNETIC TECHNOLOGY

TITLE: EXPLORATORY RELATIVISTIC BEAM RESEARCH, RDT&E CATEGORY 6.1

OBJECTIVE: There are a number of Navy and DOD programs which utilize intense burst of energy such as can be provided by relativistic electron beams. The objective of this program is to develop new and powerful techniques for modifying such electron beams to make them more useful in these applications. A further objective is to build high current electron, ion and heavy ion accelerators.

APPROACH: The use of passive structures and perturbations have been demonstrated to produce significant modifications in relativistic electron beams. In particular autoacceleration techniques have been shown feasible for doubling the kinetic energy of beam electrons, further automodulation experiments have produced highly modulated trains of relativistic electron beam pulses.

PROGRESS: (A) A new electron accelerator that produces 4 MEV electron beams was constructed. Using an autoacceleration technique electron kinetic energy was increased to approximately 7 MEV. (B) Automodulation of intense electron beam was achieved with power level of 10(10) watts and frequency of approximately 300 MC/S.

FOLLOW-UP ACTION

ORGANIZATION: Naval Research Lab, Code 4700, Plasma Physics, Washington, DC 20375

POINT OF CONTACT: Friedman, Mosher, Dr. **TELEPHONE:** (202) 767-3145

SUMMARY OF DISCUSSION: The electron beam accelerator is a very large preliminary laboratory machine. The problems are operational and not in testing, although the high power measurements are not precise. High noise, X-ray and high frequency are all measurement problems or parameters. They "try to use conventional diagnostics and unconventional devices."

CONCLUSION AND RECOMMENDATIONS: The last phrase above might typify much of the lab test approaches used in these "6.1" type R&D tasks. Since various DOD programs will use these high energy beams and some generic measurement will be required.

TITLE: WEAPONS: HIGH EFFICIENCY FEL (FREE ELECTRON LASER) EXPERIMENTS
RDT&E CATEGORY 6.2

OBJECTIVE: The objective of this work unit is to demonstrate high efficiency at 10.6 microns in an FEL amplifier so that the theory can be verified and experimental constraints determined. These results will contribute to the design of high-efficiency high-power free electron lasers at visible wavelengths which are applicable to Navy requirements for optical weapons and communications.

APPROACH: To accomplish the proposed objective, investigations will be made of oscillator startup and steady state physics, scaling experiments from 10 microns to 1 micron and generation of high current E-beam pulses with low emittance and energy spread. System configuration and operating point will be determined theoretically and optimized experimentally. Electron beam diagnostics will be improved. Preliminary design to upgrade the BAC linac for oscillator experiments at 1 micron will be done.

PROGRESS: A 2.7 M wiggler magnet was designed and constructed using an array of SMCO magnets. The magnetic wavelength is 3.56 CM. The magnet can be used either as a constant or tapered wiggler. Tapering is achieved by varying the width of the magnetic gap. The wiggler was installed on the EGG RF linac beam line. A CW injection-locked CO(2) laser system was installed so that its output beam can be overlapped with the E-beam pulse from the linac. Peak power was measured at 40 MW. A unique electron energy spectrometer capable of measuring the energy spectrum on a single shot was installed on the beam line. Using a 4.5 percent taper on the wiggler, spontaneous emission was observed from 9.9 to 11 microns with peak output slightly below 10.4 microns. About 2 percent electron trapping was observed using a 1.5 percent taper. Average deceleration of the electrons was 0.6 percent. Trapping fraction was slightly below the theoretically predicted value of 5 percent.

FOLLOW-UP ACTION

ORGANIZATION: TRW, Inc., One Space Park, Redondo Beach, CA 90278

POINT OF CONTACT: Niel, George R., Dr. **TELEPHONE:** (213) 536-1453

SUMMARY OF DISCUSSION: Only one FEL has been built that worked (at Stanford). Question of testability is "premature" at this stage. Research is in such a degree of infancy that the device is 400 ft. long! Optical power out measurement and optical beam quality are not hard to measure and the CW electron laser is easy to measure also.

CONCLUSION AND RECOMMENDATIONS: The "easy to measure" statements are in the laboratory context, but any free elctron laser should be a large, fixed installation and special testing methodologies would be needed for such powerful systems.

TITLE: PARTICLE BEAM TECHNOLOGY, RDT&E CATEGORY 6.2

OBJECTIVE: Evaluate experimentally transmission-line cavity model S to provide design data for high-gradient electron acceleration devices with potential applications in military systems or ballistics diagnostics. Develop the technology for advanced lightweight, high gradient accelerator devices and assess their potential for military and laboratory applications. Define potential tactical Army application of charged particle beams and investigate associated technology issues in coordination with national program.

APPROACH: Complete work experiments on full scale cavity model. Determine optimum switch and charging isolator configuration for (E/T) coaxial cavity design. Demonstrate performance of optimum cavity design with proton beam acceleration. Initiate work for full voltage tests with an electron beam. 8010 - Conduct analytical and experimental investigation of transmission-line accelerator cavity concepts. Investigate alternative concepts for achieving high acceleration gradients. Define optimum beam parameters considering collective beam effects to provide input to device design and application analysis.

PROGRESS: None. Related prior work of a more basic theoretical nature is reported under accession No. DA or 4495. 79 10-80 10, a full scale two-line (E/T1) cylindrical accelerator cavity model, has been subjected to low voltage tests to investigate the effects of switch inductance and line discontinuities. The results to date confirm prior theoretical analysis and provide design requirements for a full energy device. Preliminary investigations of a three-line linear induction accelerator cavity have been made using strip lines. Results confirm theoretical analysis but reveal problems at line discontinuities which may influence application with recirculated beams. 8010-8110, a full-scale model of a three-line, transmission-line, linear-induction accelerator cavity, has been used to verify our previous theoretical analysis and to identify an internal structure for the cavity which yields an acceptable waveform for beam recirculation. This work was presented at the 1981 particle accelerator conference and subsequently published in the open literature. Analytical studies were initiated in-house to show that the Z1:Z2:Z3::1:2:6 configuration is 100 percent efficient in a beam recirculation mode. A contract was let with Science Applications, Inc., to perform a theoretical study to identify the potential problems and beam instabilities likely to arise when an intense beam is bent, as is necessary for beam recirculation. In addition, assessments of both the

current status of particle beam technology (PBT) and the outlook for PBT development and for tactical Army application were made for three different study groups representing various Army users. For one of the studies, detailed documentation was provided.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM Ballistic Research Lab, Aberdeen, MD 21005

POINT OF CONTACT: Eccleshall, D. Dr. **TELEPHONE:** (301) 278-5889

SUMMARY OF DISCUSSION: Particle beam technlogy is in concept feasibility and high risk. R&D test equipment needs not identified yet. The Army contact stated that the Navy and Air Force are ahead in this R&D area. Operational field configuration is unknown, but may be smaller than experimental models.

CONCLUSION AND RECOMMENDATIONS: Reasonable test or measurement needs will not be available in some R&D areas such as this, for a year or two, SD JLC needs periodic follow-up to avoid missing the problem.

TITLE: KARL INITIATION, RDT&E CATEGORY 6.1

OBJECTIVE: To develop a large-aperture discharge pumped excimer laser and utilize it for the investigation of the following: the physics of very large fresnel number laser cavities, the effect of medium inhomogeneties on laser beam quality, and the scaling of frequency conversion and beam corrective techniques to large apertures.

APPROACH: Under KARL initiation, the X-ray preionized discharge pumped excimer laser will be scaled from its present 1 liter volume to 30 liters. Prior to the final design of the 30 l device which will have an aperture of 20 CM X 15 CM, a test laser of 10 CM X 7.5 CM aperture will be constructed. The test laser will be used to determine optical electrode configuration and limitations on pulse duration.

PROGRESS: The successful operation of the test laser has set a new record of 70 CM2 aperature for discharge pumped excimer laser (compared to the previous maximum of approximately 25 CM2). At the highest operating pressure of 3 ATM attempted so far, an energy of 6 J has been extracted from XECl. No degradation in laser efficiency is discernable at the larger discharge aperture. In a series of highly significant experiments, the output of electrodes was deliberately made to be slower. The implication is that one may be able to eliminate the rail gap switch between the water line and the laser head, which is the lifetime limiting component of the overall system.

FOLLOW-UP ACTION

ORGANIZATION: NRL Optical Science (Code 6540), Washington, DC 20375

POINT OF CONTACT: Djeu, N. I. Dr. **TELEPHONE:** (202) 767-2955

SUMMARY OF DISCUSSION: Experiments require measurement of laser pulse shape, wavelength, etc. (no problems here) using off-the-shelf equipment. Possible problem area for testing, however, could be the development of an instrument to measure output for high energy laser devices. Energy meters are presently on a custom basis.

SECOND FOLLOW-UP ACTION

ORGANIZATION: Same

POINT OF CONTACT: Hall, George E. **TELEPHONE:** (202) 767-2955

SUMMARY OF DISCUSSION: He agrees that energy meters are usually home-built affairs. Also there are very few energy devices around. There have been different approaches (rather complex) which have evolved, usually water cooling and temp rise measurement (colorimetry) type of technique. Other direct energy measurement techniques have apparently not evolved.

CONCLUSION AND RECOMMENDATIONS: The need for JLC attention and funding to the problem of direct energy measurement is forcefully stated here by two contacts.

TITLE: ADV CONCEPTS IN HIGH POWER MMW GENERATION, RDT&E CATEGORY 6.1

OBJECTIVE: To invent and demonstrate new types of high power millimeter wave tubes which promise to satisfy projected DOD system requirements that cannot be met by incremental improvements in existing millimeter wave tubes. Ultra-wideband amplifiers as well as very high frequency devices (90 GHz and above) are of special interest.

APPROACH: (1). Research on the distributed gyrotron travelling wave amplifier (GYRO-TWA) concept to obtain ultrawide bandwidth; (2). research on the Slow Wave Cyclotron Amplifier (SWCA) concept to demonstrate a new microwave interaction mechanism potentially advantageous for ultrawide bandwidth operation; (3). research on the gyro-klystron to achieve a new type of MM wave gyro-amplifier featuring high gain and efficiency; (4). research on second cyclotron harmonic gyro-TWA to explore the possibility of MM wave amplification without superconducing magnets.

PROGRESS; (1). A comprehensive gyro-TWA theory and design code has been developed; (2). the design code has been employed to accomplish several distributed gyro-TWA designs and a second harmonic gyro-TWA design; (3). a proof-of-principle experiment has been successfully conducted. It demonstrated a 13 percent bandwidth, a five-fold improvement from previous results; (4). experimental test of a dielectric loaded SWCA has begun; (5). experimental preparations for testing a periodically loaded SWCA has begun; (6). a gyro-klystron theory has been developed.

FOLLOW-UP ACTION

ORGANIZATION: NRL Plasma Physics Div, (Code 4740), Washington, DC 20375

POINT OF CONTACT: Chu, K. R. Dr. **TELEPHONE:** (202) 767-4148

SUMMARY OF DISCUSSION: Dr. Chu said that his facilities measure the gyrotrons adequately at 35 GHz, but the higher frequency MMW windows such as 120 or 240 GHz are definite test problems.

CONCLUSION AND RECOMMENDATIONS: Dr. Chu did not mention the high power measurement problem and his ability to handle 35 GHz may not relate to field test equipment.

TITLE: PENIOTRON TECHNOLOGY II, RDT&E CATEGORY 6.2

OBJECTIVE: To fully assess the potential of a new fast wave interaction scheme, called peniotron, and develop technology necessary for its engineering design.

APPROACH: The peniotron is a relatively new fast wave interaction device which holds promise to fill the gap of intermediate powers at millimeter wave frequencies. The most difficult task of demonstrating a practicable gun design has been accomplished in an initial technology program (F33615-79-C-1714). At the same time, a small signal theory has been developed which allows a general overview on expectable device performance. Phase II will integrate these new technology elements into an experimental lab device for a practical technology demonstration and an assessment of RF performance, industry quantitative correlation between theory and experiment.

PROGRESS: 810316-820331. The aim of this program is demonstration of a new interaction concept and general performance assessment. Convincing demonstration was accomplished by performance of an 8 GHz peniotron oscillator design which at the end of a testing period delivered 2 KW RF power at over 30 percent efficiency. Higher mode operation was

demonstrated. A subsequently built 16 GHz device showed 20 W output. It could, with observable outputs, be operated up to the 9th harmonic. Efforts are under way on correlating more completely the experimental and theoretical results.

FOLLOW-UP ACTION

ORGANIZATION: Avionics Lab (Microwave Branch), Wright-Patterson AFB, OH 45433

POINT OF CONTACT: Fritz, Walter **TELEPHONE:** (513) 257-2989

SUMMARY OF DISCUSSION: The peniotron is intended to be an intermediate power MMW, to replace a TWT. Mr. Fritz stated that TWT test techniques should work, although at higher frequency.

CONCLUSION AND RECOMMENDATIONS: Another example of a MMW device requiring new test equipment with more power to measure than most other MMW items.

TITLE: HIGH POWER MICROWAVE TUBE COMPONENT, RDT&E CATEGORY 6.1

OBJECTIVE: Recent advances in high-power microwave technology have led to interest in exploring the potential of this technology for Naval applications. The objective is to improve technology relating to high-power microwave components to increase output pulse length of the relativistic magnetron.

APPROACH: Modify the Hybrid Inverted Coaxial Magnetron (HICM) for microsecond pulse length operation, design and fabricate a self-aligning test bed structure for the HICM. Assemble, cold test and characterize the RF output waveguide high-voltage stand-off and vacuum window components.

PROGRESS: Modifications, assembly and cold tests complete characterization complete. Dissassembly in progress. Multi-funded, work units & sponsors are: 0866-11 ONR 18,972 0868 12 AIR 114,915; total to date: 133,887 915; total to date: 133,887.

FOLLOW-UP ACTION

ORGANIZATION; NRL Plasma Physics Div. (Code 4742), Washington, DC 20375

POINT OF CONTACT; Read, Mike Dr. **TELEPHONE:** (202) 767-4004

SUMMARY OF DISCUSSION: Dr. Read described the Hybrid Inverted Coaxial Magnetron (HICM) as having very high power (100 gigawatt) and very short pulse (less than 50 nanosecond) device. Being very early in "6.1" category it is early in development and testing has not been addressed.

CONCLUSION AND RECOMMENDATIONS: Another example of a high power, short pulse measurement problem area, but this is too early to identify test philosophy. There is no test equipment for these factors and development is required.

TITLE: GYROCON RF AMPLIFIER DEVELOPMENT, RDT&E CATEGORY 6.1

OBJECTIVE: The gyrocon is a very efficient converter of DC to RF power. Only two such devices have been built, both in the Soviet Union. The first Soviet device produces 40 MW of peak power at 430 MHz, while the second produces 1.0 MW CW at 181 MHz. Two computer codes to simulate these devices have been written at LASL and used to evaluate the potential performance of this family of devices. The computer analysis indicated that overall efficiencies of 90 percent should be obtainable and very large output powers of several MW per device are obtainable in the 200 to 800 MHz frequency range. A gyrocon with 600 KW CW output power at 450 MHz was designed with these codes. This first LASL gyrocon has been designed and is now being built.

APPROACH: The Mark I, 600 KW model will be tested in both the pulsed and CW modes. A control system to protect the device and to automatically adjust the various voltages and currents will be designed and implemented. The design work on the Mark II gyrocon rated at 2 MW will begin.

PROGRESS: 811118-820526. Technical management review conducted 3 May 1982. The multipactor problems have been partially resolved and the gyrocon is presently producing 150 KW CW output RF power.

FOLLOW-UP ACTION

ORGANIZATION: AF Weps Lab Advanced Concepts, Kirtland AFB, New Mexico 87117

POINT OF CONTACT: Straw, David TELEPHONE: (505) 844-0333

SUMMARY OF DISCUSSION: The gyrocon converts DC to RF at 600 KW of power. It is tested with general purpose test equipment by taking off a fraction of power from the waveguide and attenuating it. This is inexact to say the least.

CONCLUSION AND RECOMMENDATIONS: ATE for high power microwave devices are needed, but the need was not considered critical by the contact. Frequencies up to 500 MHz are in the test stage now.

TITLE: CIRCULAR ADAPTIVE ARRAYS, RDT&E CATEGORY 6.1

OBJECTIVE: Development of new adaptive array antenna systems techniques for the effective suppression of RF interference, keeping in mind their ultimate application to airborne platform systems for radar and communications.

APPROACH: Theoretical analysis and computer simulation of promising new ideas, algorithms and techniques to evaluate their performance characteristics. Whenever feasible, selected array antenna configurations will be coupled into a laboratory receiver processor to obtain additional experimental evaluation.

PROGRESS: The investigation of high-performance eigenvalue/eigenvector decomposition analysis techniques has continued and they demonstrate characteristics which are very suitable to a wide range of applications. They can be conveniently implemented as an algorithm to provide asymptotically unbiased estimates of the number of signals present, directions of arrival, relative strengths and coherence. Signal-to-noise ratio (SNR) sensitivity is as good as theoretically possible. They have been applied to multiple source situations which include mixtures of coherent and non-coherent sources of unequal strengths, and the simulations stimulate optimistic implications regarding the simultaneous accurate tracking of closely spaced multiple sources/targets.

FOLLOW-UP ACTION

ORGANIZATION; MICOM Army Missle Laboratory, Redstone, AL 35809

POINT OF CONTACT: Russell, Robert F. **TELEPHONE:** (205) 876-4061

SUMMARY OF DISCUSSION: This work is just beginning (re-funded) and Mr. Russell had no problems with instrumentation to date. He suggested someone call him again about the end of the year.

CONCLUSION AND RECOMMENDATIONS: Too early to identify test instrumentation needs.

TITLE: POLARIMETRIC TECHNOLOGY SEEKER, RDT&E CATEGORY 6.2

OBJECTIVE: The objective of this effort is to provide a polarimetric technology seeker that is capable of exploring the acquisition, discrimination and terminal guidance improvements that can be obtained utilizing polarimetric technology. Doppler systems cannot be used against stationary targets, polarimetric processing systems which electronically move the targets scattering centers around and discrimination on this basis is the only known solution.

APPROACH: A brassboard 17 GHz polarimetric radar was built by Martin and, when tested, showed many areas that required redesign to adequately measure the polarimetric parameters of targets and clutter. This basic radar will be enhanced to provide a polarimetric technology seeker to explore this emerging technology.

PROGRESS: The basic multi-environment active RF seeker (MARFS) has been delivered to the contractor for redesign and refurbishment along with required GFP.

FOLLOW-UP ACTION

ORGANIZATION: MICOM Army Missile Laboratory, Redstone AR, AL 35809

POINT OF CONTACT: Russell, Robert F. **TELEPHONE;** (205) 876-4061

SUMMARY OF DISCUSSION; A special tester is anticipated to measure multiple facets of polarimetric technology and processing. Still modifying brassboard design.

CONCLUSION AND RECOMMENDATIONS; Another challenge to the goal of standardized, multi-purpose ATE with on-line BIT possible performing the most critical checks.

ELECTRO-OPTICAL TECHNOLOGY

TITLE: NEAR MILLIMETER WAVE RADAR TECH, RDT&E CATEGORY 6.2

OBJECTIVE: The objective of this contract is to develop a NMMW radar system operating in the 1.3MM atmospheric transmission window to evaluate all-weather target acquisition at this wavelength. Also, radiometric receivers at 215 GHz and 135 GHz are being developed under this contract for passive detection of targets in poor visibility conditions.

APPROACH: The radar system will consist of an extended interaction oscillator transmitter, an W/4 subharmonically pumped mixer receiver, quasi-optical duplexer and a gimbal mounted antenna system to search for the field-of-view. These components are being developed as a part of this program since they are not available commercially at this frequency.

PROGRESS: 80 09-81 08 extended interaction oscillator transmitter is operational at 225.5 GHz. Phase locking circuit is being developed to lock E10 with phase locked Gunn local oscillator reference. Width/4 subharmonic mixers have been built with a 10 dB mixer noise figure for radar receiver and phase lock circuit. Final system design and component layout for system is complete and final parts being machined. The 135 GHz radiometric receiver, rexolite lens and 135 GHz horn have been delivered. The 215 GHz radiometer receiver is being tested.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Night Vision & E-O Lab, Ft. Belvoir, VA 22060

POINT OF CONTACT: Trussell, C.W. **TELEPHONE:** (703) 664-5364

SUMMARY OF DISCUSSION: The type of spectrum analyzers needed are currently special order and take along time delay for delivery. MMW is being tested at lower intermediate frequencies, assuming mixers and detectors are good. Would expect BIT and monitoring also at lower frequencies, such as noise figure and frequency checks. The brassboard system is being tested with lower RF test equipment, local oscillators and lights.

CONCLUSION AND RECOMMENDATIONS: This was one of the most specific responses on MMW testing methodologies and requirements. The lower frequency spectrum analyzers and other test equipment need to be replaced by new MMW capable equipment to avoid the present lab test equipment. The field will have more difficulty as usual.

TITLE: FAR INFRARED AND SUBMILLIMETER QUANTUM ELECTRONICS 17141-P
RDT&E CATEGORY 6.1

OBJECTIVE: Development of tunable submillimeter sources. Relevance. The research directly impacts the Army's near millimeter plan and the 8-1000 GHz plan. The millimeter beamrider program and the STARTLE program will also benefit from the results of this program. BMDATC has already utilized detectors developed during the previous contract.

APPROACH: The following areas will be investigated: (1) tunable sources: GaAs tunnetts and arrays of planar diodes, INP oscillators, type I and II superlattices in GaAs; (2) work on receiver technology to integrate planar diode mixers, antennas and FET IF amplifiers on a single chip; (3) use the above developed components in the folowing spectroscopic measurements; possibility of up-conversion from the submillimeter to the visible region, saturation spectroscopy of shallow donors in semiconductors and Rydberg states in gases.

PROGRESS: 8003-8112 for possible submillimeter device applications, layers of GaAs, GAXAL1-XAS and GaAs/GAALAS heterostructures have been grown by MBE. Sub-Doppler submillimeter spectroscopy has been carried out using molecular beams. GaAs Schottky diodes have been used as cooled mixers, as well as mixers of 10 microns radiation at room temperature. A monolithic mixer, consisting of a slot antenna coupled to a planar diode, has been operated at 110 and 350 GHz. A number of applications of the newly developed submillimeter technology have been demonstrated.

FOLLOW-UP ACTION

ORGANIZATION: Massachusetts Institute of Technology, Lexington, MA 02173

POINT OF CONTACT: Tannenwald, P.E. TELEPHONE: (617) 863-5500 X-5822

SUMMARY OF DISCUSSION: This work is on monolithic MMW devices and device testing that is felt not applicable to field testing. Application to system and system testing is in the future. Not much is instrumented above microwave frequencies, into MMW and above. Test equipment suppliers need to develop MMW test instruments. In summation, "the high end of millimeter world needs more instrumentation."

CONCLUSION AND RECOMMENDATIONS: The final sentence above is a concise summary of the MMW test situation. The JLC objective to fill that gap is a mandate for multi-purpose portable field MMW ATE.

TITLE: **NMMW OPTICALLY PUMPED SOURCES, RDT&E CATEGORY 6.1**

OBJECTIVE: The near-millimeter (NMM) portion of the spectrum. 0.3-2.5MM, will play an important role in close support, remote sensing systems which (1) operate well under smoke, inclement weather or cloud environments; (2) provide high resolution capability and (3) are secure in terms of countermeasure vulnerability. NMMW technology addresses these requirements being an attractive compromise between the high resolution capability of IR systems and the low propagation losses characteristics of microwave operation. The objective of this program is to foster and contribute to the development of the technology base in this relatively unexplored portion of the EM spectrum.

APPROACH: The NMM technology program is based upon three complimentary approaches. First an in-depth study is being conducted of the state-of-the-art to define current and future systems requirements and identify technology gaps and research efforts to fill these gaps. Second, an in-house research program is underway for the development of NMMW sources which have practical power/size capabilities and high spectral purity. The third portion of this program is an out-of-house effort in the three areas of sources, receivers and progagation effects.

PROGRESS: A sealed-off RF-excited CO2 waveguide laser was procured for use as a more compact and more portable optically pumped laser than that used previously. Besides the reduced size, the CO2 waveguide laser has a greater frequency tunability which permits optimal pumping of already known NMMW laser lines with large infrared absorption frequency displacements from TEH CO2 line center. The waveguide laser was used to pump several gases already known to efficient NMMW laser molecules including 1, 1-Difluoroethylene, CDF3 and CD2F2. In addition to more nearly optimal pumping of a number of transitions, 17 new low threshold lines were found. The absorbing transitions for the new lines were all beyond the tuning range of a conventional pump CO2 laser.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Harry Diamond Center, Adelphi, MD 20783

POINT OF CONTACT: Sattler, J.P. **TELEPHONE:** (202) 394-2042

SUMMARY OF DISCUSSION: MMW lacks test instruments; power is also a problem. Intensity is more difficult than frequency to measure. This project is into optical and visible spectrum. Primary research for Army equipment, but applicable to various MMW programs.

CONCLUSION AND RECOMMENDATIONS: This reinforces the MMW frequency and power test problems previously noted on other task follow-ups.

TITLE: HEL ADVERSE WEATHER FIRE CONTROL/AQUISITION RADAR (HAWFCAR)
RDT&E CATEGORY 6.3

OBJECTIVE: The HAWFCAR is a 6.3A advanced development program of a heliborne experimental radar system capable of detecting, acquiring, classifying airborne and ground targets and providing an aid to navigation.

APPROACH: The HAWFCAR program is a three-phase program consisting of preliminary design, detail design, system fabrication and test, AH-64 helicopter integration and test, and flight tests. The program is designed as a competitive fly-off of different radar technical approaches under a firm fixed price contract with Hughes helicopters performing aircraft integration under a cost plus contract.

PROGRESS: This contract was awarded on 29 September 81 for $6,550,000.00.

FOLLOW-UP ACTION

ORGANIZATION: AVRADCOM R&T Labs Applied Technology, Ft. Eustis, VA 23604

POINT OF CONTACT: Quinn, John **TELEPHONE:** (804) 878-2772

SUMMARY OF DISCUSSION: Funding was cut for FY83. There are considerable MMW testing problems, due to lack of test equipment. Other MMW programs have the same experience.

CONCLUSION AND RECOMMENDATIONS: This Army helicopter radar problem is another MMW test instrumentation problem example.

TITLE: DETECTOR/MIXER ELEMENTS, RDT&E CATEGORY 6.1

OBJECTIVE: To provide rugged sensitive detectors for near-millimeter wave radiation. New solid state materials and mechanisms will be explored.

APPROACH: Photoconductors, such as INSB and HGCDTE, will be tested for near-millimeter sensitivity through either a hopping or hot-electron mode of operation. Both video and mixer characteristics will be determined. Enhanced detector performance will be pursued through temperature and cyclotron studies.

PROGRESS: Hot electron photoconductive detection of near-millimeter wave radiation has been observed for the first time using the alloy-semiconductor HG,CD TE. Spectral response from 0.1 to 4.0 millimeters wavelength has been determined. At a wavelength of 3 mm a noise

equivalent power of less than 10-12 W/square root Hz and a reponse bandwidth greater than 25 MHz has been measured. In addition, the responsivity has been enhanced by a factor of over 30 through the application of a 20 KG magnetic field. A final report is in progress.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Harry Diamond Lab, Woodridge, VA 22191

POINT OF CONTACT: Weber, B.A., Dr. **TELEPHONE:** (202) 394-3170

SUMMARY OF DISCUSSION: The lab could test the MMW sensitivity detectors adequately. Dr. Weber said he was not involved in test instrumentation. After these opening statements, Dr. Weber refused to discuss the project anymore over the phone. He referred to government sensitivity to R&D work.

CONCLUSION AND RECOMMENDATIONS: This was one of the few instances of refusal to talk over the telephone about status of R&D testing. Some others wanted to write down information on who was calling, affiliation, etc., prior to talking. The government technology leak fixation may be a future problem in efforts such as this.

TITLE: RESEARCH ON EIGEN MODE RF GENERATION, RDT&E CATEGORY 6.1

OBJECTIVE: This program is to deepen the understanding of a newly discovered highly promising wave particle interaction scheme and explore its practical applicability to the generation and amplification of RF millimeter wave power. Baseline technology, present millimeter wave power tube technology, has been unable to provide the required bandwidths and output powers at economically affordable unit costs. ECM power levels are beyond the present solid state technology; therefore, thermionic technology will be required. AF requirements: planning of new ECM systems required power/bandwidth performance which calls for significant advances in power tube technology.

APPROACH: The theory of the new interaction scheme predicts very large bandwidth operation at suitable powers to be obtained with reasonable voltages (10 to 30 kv) and magnetic fields (2 to 5 Kgauss) without the need of a complicated slow wave structure. Generally, the study will investigate how these findings will translate in a projection for a device. Specific items of investigations are (1) the requirement and possible solution for suitable electron optical system, (2) broadband couplers at RF input and output of such a device, (3) numerical modeling of device performance and (4) performance boundaries in millimeter wave regime.

PROGRESS: None

FOLLOW-UP ACTION

ORGANIZATION: Avionics Laboratory (Microwave Tech), Wright-Patterson AFB, OH 45433

POINT OF CONTACT: Fritz, Walter **TELEPHONE:** (513) 255-2989

SUMMARY OF DISCUSSION: No unique test equipment anticipated. Should test like TWTs. Unknown equipment application due to early status in 6.1. A fast wave device classification system developed, but still theory.

CONCLUSION OF RECOMMENDATIONS: It is anticipated that this will prove to be another MMW test problem in the field.

TITLE: INFRARED SURVEILLANCE AND TARGET ACQUISITION RADAR FOR TANK LOCATION AND ENGAGEMENT (IR STARTLE), RDT&E CATEGORY 6.2

OBJECTIVE: Demonstrate feasibility of a carbon dioxide laser radar system for use as a multifunctional target acquisition device for advanced combat vehicle and aircraft application under adverse atmospheric conditions.

APPROACH: Develop and test a coherent laser radar testbed/demonstrator system capable of automatically classifying targets using high resolution three dimensional target sensing techniques. High range resolution will be obtained in the radial direction using sinusoidal amplitude modulation and phase detection techniques. Vibration sensing will be considered for additional target discrimination capability and a low cost digital processor may also be included.

PROGRESS: 8105-8206, originally it was planned that this effort would result in a coherent laser radar imaging system Doppler MTI techniques. The program was not funded above a very minimal level, however, and fabrication was never initiated on that design. A new program concept is now in the process of being implemented based on the 3D technique. Additional funding has been added to the contract and design of the system has just begun.

FOLLOW-UP ACTION

ORGANIZATION: Raytheon Co., Sudbury, MA 01776

POINT OF CONTACT: Jelalian, A.L. **TELEPHONE:** (617) 443-9521 X-3121

SUMMARY OF DISCUSSION: Research involves IR in 10 micron range. There are many problems with measurements and instrumentation. Mr. Jelalian states that little effort has been expended and, therefore, standard targets and standard test technologies for active systems are "not existent." Raytheon had to develop their own test techniques and technology. As an example, with a range finder they have had detector nonuniformities affecting measurements. The calibration of detectors (being used differentially) is a problem, even after having some calibrated to NBS standards, since application is different. This results in having to prove the accuracies of their tests involving excessive expenditures of man-hours. There are existing, well-developed techniques for passive systems, but these do not apply to active systems; resolution, sensitivity, standard test targets, etc., are all problems.

CONCLUSION AND RECOMMENDATIONS: This contact provided specific test problems and even requested that the test technology office contact him to help provide guidance. This IR STARTLE program is a major Army tank laser project.

TITLE: LASER RADAR TECHNOLOGY, RDT&E CATEGORY 6.2

OBJECTIVE: To advance generic technlogy of laser systems for weapon control in shipboard defense application. Specifically to develop and demonstrate laser radar technology capable of providing precise tracking of multiple targets.

APPROACH: This is an integrated in-house and contract program to (1) perform system analysis including interface with search radars and with intercept missiles, (2) develop the transmitter, receiver and pointing optics and (3) integrate them into a demonstration test unit which will prove the unique capability of a laser radar system for tracking multiple high speed targets in a realistic marine environment.

PROGRESS: Work has progressed on the trailer-housed laser radar experimental test unit. The laser head has been installed in the flow system. Transmitter pulse modulator was completed. Receiver optics are currently being mounted. Work on signal processing electronics was resumed after interruption, hardware fabrication is nearly completed. Initial measurements comparing heterodyne and direct detection efficiency have been obtained (for simple reference target).

FOLLOW-UP ACTION

ORGANIZATION: Naval Surface Weapons Center, Dahlgren, VA 22448

POINT OF CONTACT: Graham, Walter J. **TELEPHONE:** (202) 394-2091

SUMMARY OF DISCUSSION: Mr. Graham pointed out several potential problem areas: the testings of shipboard laser radar fire control may be a problem due to hostile shipboard evironment, e.g., missile launching, gun firing, smoke, debris. Electro-optical systems employ very sensitive detectors and there may be RFI problems due to radar transmitter interference should the laser radars be tested aboard ships. Launchings and firings may cause optical attenuation and scattering. Pointing errors in alignment may be a problem with precision tracking using laser radars. How can it be tested, verified and maintained aboard a flexing, moving ship platform? Pointing errors are expected between the search radar and the laser radar weapon control due to such flexures.

CONCLUSION AND RECOMMENDATIONS: This response keyed on the unique field testing environment of a ship at sea. These put severe constraints on the ATE which must be considered by the JLC when designing and contracting for test instrumentation.

TITLE: CARBON DIOXIDE LASER RANGEFINDER, RDT&E CATEGORY 6.2

OBJECTIVE: To provide a rangefinder which can be integrated into the M-1 gunner's primary light for ranger compatibility with vehicle weapon system both day and night and allow improved performance under poor visibility conditions, such as reduced visibility caused by smoke, dust, and haze.

APPROACH: A laser rangefinder operating in the 10.6 micron region will be designed to replace the 1.06 micron ND:YAG laser currently in the M-1 tank which effectively utilizes existing vehicle space, power and support equipment while maintaining critical interfaces with on-board computers and fire control assemblies.

PROGRESS: 8108-8202 contract awarded. Design and fabrication initiated.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Night Vision/E-O Labs, Ft. Belvoir, VA 22060

POINT OF CONTACT: Spector, Dave **TELEPHONE;** (703) 664-5286

SUMMARY OF DISCUSSION: The problem is the measurement of pulsed laser output at 10.6 microns. The following two areas stand out: (1) Typically, pyroelectric detectors are used. These are dependent upon intensity at the focal spot. Sensitivity blowoff at the plasma area effects the detected electrical signal output. Most pyroelectric detectors are also piezo-electric in nature so they act like a microphone and respond to sound energy. (2) Problem with measuring beam divergence -the cross section profile at the far-field. (a) Atmospheric turbulence

breaks up beams. (b) Speckle, which is interference due to coherent light scatter when incident surface irregularities, are in order of one wavelength. If speckle cells are in order of size comparable to one wavelength, they cause bright and dark spots.

Because of above problems, two different operators can make the same measurements using the same equipment and experience 25 percent disparity in their results. Dave suggests the following two ideas for development: use of smooth and textured surfaces side-by-side to cancel out speckle effects and need for development of a reflectance standard for test targets. Perhaps, an inflatable or window shade type of object to protect surface and guarantee a uniform, predictable reflectivity.

CONCLUSION AND RECOMMENDATIONS: This follow-up targeted on operator and reflector details of laser measurement and the need for JLC reflection standards. Naturally the design of laser field ATE should be sensitive to these points.

TITLE: MODULAR MULTIFUNCTIONAL CW CARBON DIOXIDE LASER DEVICES RDT&E CATEGORY 6.2

OBJECTIVE: The objective is to provide a reliable, efficient, environmentally hardened and frequency stable far infrared laser transmitter for specific military laser radar requirements. The application will require Moving Target Indication (MTI) through Doppler shift sensing, target ranging and radical velocity determination.

APPROACH: The approach is to develop a rugged 15 to 20 watt FM-CW waveguide carbon dioxide laser transmitter using state-of-the-art PZT technology for dither stabilization and frequency chirping. A simple receiver will also be developed to validate the adequacy of the transmitters to perform the intended functions. Short term frequency stability will be approximately 30 KHz.

PROGRESS: 8009-8108 The original objective of developing a stable 20 watt transmitter has been changed. Loss of system signal-to-noise ratio due to nonlinearity of chirping with the 20 watt cavity would be larger than the gain due to increased power output. A 10 watt transmitter was, therefore, decided upon. The transmitter has been fully developed and with improvements in PZT technology, has shown a 1 percent linearity of chirp. The scope of work is being modified to include development of the interferometer to be used in the IR STARTLE laser radar system.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Night Vision/E-O Lab, Ft. Belvoir, VA 22060

POINT OF CONTACT: Fox, C.S. (Woody) **TELEPHONE:** (703) 664-4931

SUMMARY OF DISCUSSION: This effort is a long way from becoming operational. However, in the future it may require some development in calibration standards, laser output, power measurement and detector sensitivity.

CONCLUSION AND RECOMMENDATIONS: The comments of laser transmitter needs for calibration, power and detector parameters are applicable to all JLC laser systems and good instrumentation goals.

TITLE: PROJECT TAU II, LS-14 LASER SYSTEM ASSEMBLY AND TEST RDT&E CATEGORY 6.3

OBJECTIVE: This project supports development of advanced laser systems. Current high energy laser systems are limited by size, power, beam quality and scale-up potential. This effort will assemble and test hardware developed under two prior technology development efforts. The assembled device is designed to have excellent scale-up potential for a compact high energy laser system. The expected high optical beam quality of this laser should also improve the effective range of high energy laser systems.

APPROACH: This contract is a follow-on to projects Sigma and Tau. Under project Tau II, the cylindrical gain generator and the annular resonator optics will be assembled into a working laser system. After laser assemble, beam diagnostics installation and control systems check out, this first-of-a-kind high power chemical cylindrical laser will be evaluated through extensive testing and analysis.

PROGRESS: 820301-820712 Technical management review conducted 14 May 82. Work commenced on the Tau II contract on 3 May 1982. Facility modification is proceeding on schedule.

FOLLOW-UP ACTION

ORGANIZATION: AF Weapons Lab (ADV OPTICS), Kirtland AFB, N. Mex. 87117

POINT OF CONTACT: Walker, Tom, Maj. **TELEPHONE:** (505) 844-0721

SUMMARY OF DISCUSSION: Large colorimeters developed by NRL are proving adequate for energy measurement. Major Walker does not consider energy meters to be a significant problem. He considers the following as possible problem areas: (1) Laser wavefront analysis (phase as it exits laser) called laser wavefront analyzer (this is "marginal at best") upgrades of state-of-art are needed, not straightforward nor off-the-shelf, only a few exist (to determine distortions on wavefront). (2) Beam quality (in far-field), probably only a lab measurement, not looked at in deployed equipment. (3) Beam jitter that impacts overall system performance. Somewhat simple now. Probably not a problem in deployed field equipment.

CONCLUSION AND RECOMMENDATIONS: Major Walker was one of the rare contacts who felt that laser energy measurements were no problem, but his identification of wavefront analyzer as a problem is deserving of JLC test committee consideration for development.

TITLE: ALPHA I DESIGN (DARPA), RDT&E CATEGORY 6.2

OBJECTIVE: AF function: laser technology, for aerospace applications. (2) Deficiency: lightweight, compact, high energy laser devices, (3) Objective--design a cylindrical HF gain generator, assciated resonators and a ground test facility, conduct hardware demonstration of scalable technologies. (4) How work contributes: a detailed design of a ground based high energy laser system will be completed for follow-on hardware technology demonstration.

APPROACH: The Alpha I program is a Defense Advanced Research Projects Agency (DARPA) sponsored program (PE 62611E). It is a parallel competitive two-phase (priced-option) program between two contractors, Rocketdyne (RD) and TRW. Phase I focuses on the Alpha I element and includes computer modeling of the internal flow structure and optics, system and subsystem analytical investigations, scaling analyses and laboratory type verification experiments. Phase I will culminate in the Alpha I element PDR. At this time one contractor will be selected to proceed into Phase II which is the detailed design of both the Alpha I device and its associated test facility.

PROGRESS: 820630-820722 TRW initiated trade studies to determine methods by which the follow-on Phase III costs, the fabrication and test phase, may be reduced to produce an improved cost effective program. To date they have been successful and have produced a prospective 30 percent cost savings. The biggest savings has been in the change of mirror coatings. The proposal to implement program changes has been received, evaluated and is being negotiated. Completion is expected in September 1982. The Phase II kick-off meeting was held in May 1982. The Hexdarr resonator design has been improved in terms of simplifying mirror fabrication which will save costs. Independent resonator analysis has shown TRW's analytical results to be valid. The mirror coating options are still being evaluated before finalizing the design. A Chemical Laser Scaling Program (CLASP)

experiment is being initiated to acquire detailed resonator data. The Gain Generator Assembly (GGA) thermostructural behavior is yet a concern, so a materials test program and a three-dimensional (3-D) analysis are being initiated to address the issues. AFWL will also conduct complimentary 3-D analysis to better understand the thermostructural integrity of the GGA. The facility design is progressing well and its PDR is scheduled for Oct 82. The next quarterly review was scheduled for late August 1982.

FOLLOW-UP ACTION

ORGANIZATION: AF Weapons Laboratory (Special Proj), Kirtland AFB, N. Mex. 87117

POINT OF CONTACT: Chand, Amer **TELEPHONE:** (505) 844-1769

SUMMARY OF DISCUSSION: A total test facility for overall system checkout does not exist and none is planned. Such a facility should be developed. Suggest test technology office follow up by talking directly with Mr. Chand for further details. Contact was somewhat reluctant to provide much information on basis of a "cold" phone call and said a letter of introduction from Program Manager was required to have his approval to talk to TRW also.

CONCLUSION AND RECOMMENDATIONS: This was the only DARPA program contacted, and the second contact who was reluctant to discuss the program over the phone. The need of a total test facility for the High Energy Laser (HEL) would be a unique, special testing equipment and probably outside of JLC concern.

TITLE: REMOTE DETECTION OF BIOLOGICAL AEROSOL CLOUDS, RDT&E CATEGORY 6.2

OBJECTIVE: Remote detection of biological threat aerosols to include range information. Determine suitability of concept for unit defense and reconnaissance applications.

APPROACH: Detection of biological aerosols by UV LIDAR through laser excitation of biological flourescence, to include a ranging capability of the detected signals.

PROGRESS: 8102-8202 Fabrication of a detection system, incorporating the LIDAR fluorescent concepts has been completed. Operational problems revealed during initial testing have been resolved. Additional testing was conducted to determine the technical operating specifications of that LIDAR/LIF remote biological aerosol detection system to provide a basis for accurate measurement of backscattered UV energy and laser

induced fluorescence energy. A component analyses of the entire LIDAR/LIF system was made to determine maintenance requirements (parts and procedures) needed to maintain stable information for one year. Contract completion of the remote biological aerosol detection alarm system is scheduled for 3Q FY82, at which time the LIDAR/LIF system will be delivered to the government. Continuing FY82 work on the system will be continued under technical area 3I, work area 02-3 (UV technology) and will include UV laboratory and field measurements using the LIDAR/LIF system.

FOLLOW-UP ACTION

ORGANIZATION: ARRADCOM Chem/Bio Detect Div., Aberdeen P.G., MD 21010

POINT OF CONTACT: Renda, J. **TELEPHONE:** (301) 671-3884

SUMMARY OF DISCUSSION: UV lasers to detect biological threats is an area in which experimental test methods are the rule. IR and UV will require special test equipment for depot and field levels. The Army and the contractor (SRI in Menlo Park) are both trying to develop instrumentation.

CONCLUSION AND RECOMMENDATIONS: UV and IR bands are both being pursued in the NBC warning system area, and both require field testing instruments. Due to the Soviet biological threat, this should be a high JLC concern.

TITLE: AIR LASER LAB (ALL) INSTRUMENTATION, RDT&E CATEGORY 6.3

OBJECTIVE: To provide a data acquisition system that can be used as tool to help align the ALL and solve technical problems encountered in the ALL. The instrumentation system will be designed and implemented in cycles corresponding to ALLs test instrumentation requirements.

APPROACH: A test data recording system will be designed and installed on the aircraft. It will be able to record multiplexed data ir an analog form. It will be able to reproduce selected data for quick-look purposes. The test data recording system will also record video data, both inside and outside the aircraft as well as receive and record telemetry data from a target.

PROGRESS: 730507-740809 This JON terminated 9 August 1974. Further reporting in this area will be accomplished under JON 317J1599 and accession number 169700.

FOLLOW-UP ACTION

ORGANIZATION: AF Weapons Lab (Laser Div.), Kirtland AFB, N. Mex. 87117

POINT OF CONTACT: Walsh, Steve **TELEPHONE:** (505) 844-3411

SUMMARY OF DISCUSSION: The Air Laser Lab (ALL) has an instrumentation system to align the ALL. It is in use and calibrated. There was no answer as to whether service personnel could test this if it were a production line deployed system.

CONCLUSION AND RECOMMENDATIONS: A system as complex and costly as this presents formidable challenges to the JLC to provide field instrumentation to users due to high power, alignment and so forth.

TITLE: HELMET MOUNTED DISPLAYS TO ENGINEERING SIMULATION B
RDT&E CATEGORY 6.2

OBJECTIVE: The Air Force is continually procuring and updating advanced aircraft and weapon systems. Engineering simulation is a research tool that can be applied to the evaluation of new concepts, designs and the integration of subsystems before the system is actually built. The objective of the effort is to investigate and develop designs for the application of a helm mounted visual display to the FDL engineering simulation facility. Such a visual display system will significantly improve the visual simulation capability of the facility, enabling more advanced concepts and designs to be evaluated early in the design phase and result in more cost effective design decision.

APPROACH: This is to be a cooperative effort with AMRL who has been the pioneer in the development of helmet mounted display (HMD) technology. Designs for a demonstration and evaluation HMD visual system for application to engineering simulation are to be developed. Existing AMRL contractor support is to be utilized for the development of these designs. The system designs are to be based on recently developed eye-piece optics, and are to consider both minature CRTs and fiber optically coupled projector image input as well as both model board/television and computer generated imagery.

PROGRESS: 811001-820423 An overall system performance analysis of the helmet mounted display system used in conjunction with the FDL terrain-board image generators has been completed. This analysis considered individual components such as the terrain board model, optical probe, television camera, video description system, display electronics, CRTs, and display optics. From predicted or measured data describing individual component performance, the overall expected system performance was predicted. The predicted system resolution performance is equivalent to

or better than that of the existing FDL visual systems. The field-of-view would be increased by at least a factor of two. The principal limiting components are the optical probe and television camera. These will be improved in any implemented system and overall system performance should be commensurate with the improvement of these components. Fiber optic coupling of imagery to the helmet display optics rather than CRTs on the helmet are being investigated as the primary means for improving resolution for future helmet visual systems for our type of engineering simulation applications.

FOLLOW-UP ACTION

ORGANIZATION: Flight Dynamics Lab (Control Synthesis) Wright Patterson AFB, OH 45433

POINT OF CONTACT: Gum, Don R. **TELEPHONE:** (513) 255-4690

SUMMARY OF DISCUSSION: Helmet-mounted displays would be computer based with BIT and diagnostics in the design. These would be in simulators for training also. Although developed by the USAF, the Army and Navy are using helmet-displays for funded tests. USAF F-4 Phantom test project was cancelled.

SECOND FOLLOW-UP ACTION

ORGANIZATION: Same

POINT OF CONTACT: Furness, Tom Dr. **TELEPHONE:** (513) 255-4820

SUMMARY OF DISCUSSION: Helmet displays present unique test problems, much of it related to the human optic functions. The equipment must be adjusted inside the cockpit. Need BIT to ensure the crew member eye is centered and exit pupil limitations are known. The boresight must align with the armament. Other test factors include coordinate systems, scaling and linearities.

CONCLUSION AND RECOMMENDATIONS: The marriage of fiber-optics, miniature CRTs and projectors with human eye simulation presents the JLC with a complex test challenge requiring miniature test instrumentation and standards. Tri-service involvement in helmet displays raise the profile of this test undertaking by the JLC committee.

AD-A132 421 TECHNOLOGY ASSESSMENT: 1983 FORECAST OF FUTURE TEST TECHNOLOGY REQUIREMENTS(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA A C MACMURRAY ET AL. JUN 83 NOSC/TD-598 2/2

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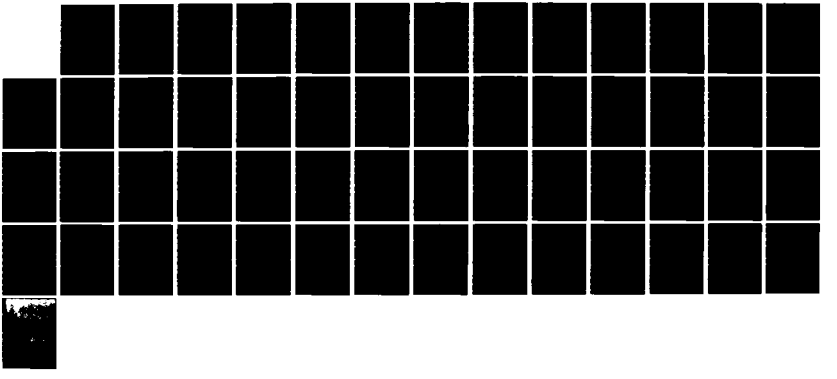

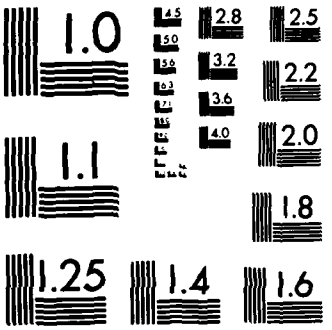

TITLE: FRESNEL LENS AND BEAM CONTROL IN OPTICAL WAVEGUIDES
RDT&E CATEGORY 6.1

OBJECTIVE: AF function-advanced Air Force weapon systems require the real-time processing of data obtained from a multitude of sensors at data rates which exceed current capabilities. Opportunity/functional deficiency: this requirement necessitates the development of analog parallel processing techniques such as optical or acousto-optical processing. An integrated optical format must be found before such processing can be realizable on-board aircraft and missiles. Objective: this research will use Fresnel diffraction in an attempt to fabricate efficient and inexpensive waveguide lenses for integrated optical systems. How work contributes: the effort advances optical processors for avionics and command/control systems.

APPROACH: Experimentally fabricated medium and high Q chirped grating lenses formed on glass substrates will be compared with the theoretical design and an attempt will be made to realize and assess the chirped grating lenses on titanium-indiffused lithium niobate waveguides. Using the generalized two-dimensional coupled-mode analysis, investigations will be conducted into curved grating reflectors, chirped grating beam splitters that will have one focused and one unfocused beam, wavelength dispersive properties of chirped grating lenses, and electro-optically active beam control. The possibility of utilizing electronic signal processing to assist guided-wave optical signal processing and vice versa, will be examined.

PROGRESS: 801001-810531 A comprehensive theoretical analysis and design data of the lens plus some experimental fabrication and evaluation results were achieved during this period. From these research results, several important conclusions have been reached: (1) Very efficient lenses (greater than 80 percent) with low F-number (less than 10) can be obtained from curved chirped grating lenses that have high Q values as long as the angular field of view can be very small. (2) Moderately high efficiency lenses (approximately 50 percent) with moderately wide field of view (about 0.1 radian) can be obtained. (3) Off-axis fresnel lenses are identical with low Q chirped grating lenses with small groove length. (4) Signal-to-noise ratio (S/N) is high (larger than 25 dB) in both off-axis fresnel and chirped grating lenses. (5) The main lobe to side lobe intensity ratio can be much larger than 13 dB, depending on the gaussian beam parameters relative to the aperture size of the lens. (6) The F-number, the aperture size and the focal length of the lens will be limited by the minimum linewidth and the precision of the line position that can be achieved by the lithographic and microfabrication methods.

FOLLOW-UP ACTION

ORGANIZATION: AF Office of Scientific Research (Solid State), Bldg. 410, Bolling AFB, Washington, DC 20332

POINT OF CONTACT: Neff, John A. **TELEPHONE:** (202) 767-4933

SUMMARY OF DISCUSSION: Although high data rate optical processing is a test concern, this fresnel lens is merely a proposed waveguide improvement and presents no new test problem.

CONCLUSION AND RECOMMENDATIONS: The fresnel lens can be tested in the same manner as traditional waveguides in the past, according to the contact.

TITLE: INTEGRATED OPTICS, RDT&E CATEGORY 6.1

OBJECTIVE: Techniques of integrated optics have been applied to specific signal processing problems related to pattern recognition and target discrimination such as correlation, complex transformations and matrix vector operations. The advantage of such techniques is increased speed and reduced package size when compared to conventional digital and analog electronic processors, as well as bulk optical processors.

APPROACH: An integrated optical discrete matrix processor has been designed for performing parallel operations basic to image processing. Modulator images provide input signal and reference information with an extended linear range and high packing density. Channel waveguides coupled to laser diode sources and silicon detector arrays form the optical paths.

PROGRESS: 8110-8207 Both planar and channel optical waveguides have been fabricated using T: in-diffusion with a L:NBO3 substrate. Channels with widths of 6 microns have been constructed with parabolic coupling lasers. Ridge waveguides have also been formed with a single mode planar region. A Bragg deflector modulator has been fabricated with a 16 micron periodicity and a 10 percent modulation efficiency.

FOLLOW-UP ACTION

ORGANIZATION: MICOM Army Missile Lab, Redstone Ars., AL 35809

POINT OF CONTACT: Duthie, Graham, Dr. **TELEPHONE:** (205) 876-3820

SUMMARY OF DISCUSSION: Dr. Duthie believes that hardware and test routines could be developed. This technology is more likely to be fielded or implemented than others, however, it is also very long term (1990s) when equipment might become operational.

CONCLUSION AND RECOMMENDATIONS: Integrated optic processors would have BIT, diagnostics and minimal ATE reliance.

TITLE: INTEGRATED OPTIC MODULES SWITCHING AND SIGNAL PROCESSING 17882-EL
RDT&E CATEGORY 6.1

OBJECTIVE: To investigate the utilization of guided-wave electrooptics and acoustooptics for high-speed multichannel light beam deflection/switching and RF signal processing. Relevance: This research is relevant to optical communications particularly to switching and multiplexing requirements at CORADCOM. It also is relevant to signal processing for radar and electronic warfare activities.

APPROACH: Multi-port optical switches and modulators with application to fiber optic and integrated optic systems will be investigated. Planar devices utilizing LINBO3 substrate material will be utilized and candidate techniques to obtain optical switching are electrooptically controlled total internal reflection, acoustooptic bragg deflection and electrooptic devices employing tilted electrodes. The incorporation of lenses on the common substrate to improve coupling to optical fibers and other integrated optic devices will also be investigated.

PROGRESS: 8104-8112 Efforts are being devoted to light beam deflector/switch/coupler using electrooptically controlled Total Internal Reflection (TIR). This particular TIR device utilizes a straight channel wavegide intersection (termed 2 delta N intersection). Contrary to the conventional intersection (termed delta N intersection), the refrative index change in the crossover region is twice that in the channel waveguides. As a result, the light wave is also guided in the crossover region and it is possible to achieve both low drive voltage and low crosstalk simultaneously by using a sufficiently small intersection angle. Measurements have been carried out on a single TIR switch/modulator capable of multigigahertz base bandwidth and a simple 4 X 4 switching matrix/network 0.75 CM total length which consists of five basic TIR switches on the same LINBO3 substrate. A simple scheme which involves cascade of identical devices for reduction of the crosstalk by a factor of two INDB, namely from -15B to -30 DB, has also been devised and verified experimentally.

FOLLOW-UP ACTION

ORGANIZATION: DARCOM Army Research Office, Durham, NC 27709

POINT OF CONTACT: Suttle, J. R., Dr. **TELEPHONE:** (919) 549-0641

SUMMARY OF DISCUSSION: Dr. Suttle felt that nobody could predict test requirements. The universities have the capability to test in the laboratory during basic research, so there are no lab testing problems. He felt that we should contact Huntsville, Alabama, or Aberdeen, Maryland, for test answers.

CONCLUSION AND RECOMMENDATIONS: Luckily, there were few individuals contacted who were so negative to intent and goals of this project, to allow JLC to get lead time on emerging test problems.

TITLE: COHERENT OPTICAL CORRELATOR, RDT&E CATEGORY 6.1

OBJECTIVE: The technical objective is to develop a compact, real-time optical correlator for use in missile terminal guidance based on in-house research.

APPROACH A correlator utilizing a GAAlAS laser diode array, a liquid crystal light valve and hlographic matched spatial filters will be made to demonstrate the principles, to utilize on a simulated mission and to evaluate engineering NG design.

PROGRESS: None

FOLLOW-UP ACTION

ORGANIZATION: MICOM Army Missile Laboratory, Redstone Ars., AL 35809

POINT OF CONTACT: Duthie, J.G. **TELEPHONE:** (205) 876-3820

SUMMARY OF DISCUSSION: The areas that could be difficult to test in operational coherent optical correlators include test alignment, modulation, light sensitivity and holographic filters.

CONCLUSION AND RECOMMENDATIONS: The above four test areas are worthy of JLC consideration for instrumentation. The anticipated wide-spread use of optical correlators for missiles and other areas make this a viable JLC nominee.

TITLE: IR SEARCH AND TRACK TECHNOLOGY DEVELOPMENT, RDT&E CATEGORY 6.2

OBJECTIVE: The technical objective is to investigate and develop new concepts and techniques for discrimination by Infrared Search and Track (IRST) systems of airborne target signatures from the infrared background clutter. These basic studies will support on-going prototype development within the Navy establishment.

APPROACH: The approach will be to (1) closely follow the various on-going programs in clutter suppression within the Navy, DOD and industry, (2) evaluate proposals for new clutter suppression techniques, (3)

advise NAVELEX 615 as to the most promising methods and (4) act as technical agents for NAVELEX on subsequent contracts in support of new concept development. Current emphasis will be to support and direct the development of adaptive multispectral IRST techniques.

PROGRESS: Data from the first field data acquisition test of the ADIRST System August, September 1981) involving multispectral records of six aircraft exercises and various clutter background scenes were reduced and analyzed. Processing optimization has begun and the system has been returned to the field for a second data collection interval to be followed by final development of the software.

FOLLOW-UP ACTION

ORGANIZATION: Naval Surface Weapons Center, Dahlgren, VA 22448

POINT OF CONTACT: Hoye, Walter **TELEPHONE:** (703) 663-7101

SUMMARY OF DISCUSSION: Infrared Search and Track (IRST) is 3 to 4 years away from engineering development model for testing. E-O is a maturing technology for surface ships with IRST and Seafire imaging fire control. Naval E-O systems need a device to measure laser PRF. There are commercial models available, but not MIL-SPEC ruggedness and transportable. Also needed is a standard bar source for FLIR resolution measurement. This would thermal stabilize at measurement temperature and use a lens to make the target appear further away from the FLIR.

CONDLUSION AND RECOMMENDATIONS: Mr. Hoye was one of the most cooperative contacts surveyed. He posed our test question to his staff engineers and called us with their feed-back, which were items one and two above. These two E-O test ideas are worthy of JLC consideration for instrumentation.

TITLE: HOLOGRAPHIC LENSES FOR MISSILE GUIDANCE, RDT&E CATEGORY 6.1

OBJECTIVE: 7908-8009 To evaluate and extend holographic optical element technology for missile guidance applications at visible and infrared wavelengths.

APPROACH: 7908-8009 Applications will be explored that take advantage of the lightweight, compactness and low cost of holographic optics. Optical systems that are difficult to implement with conventional optics will be evaluated. Of particular interest are focusing filters operating at two or more wavelengths for target discrimination and correcting elements for seeker windows. Emphasis will be placed on development of holographic elements operating at far infrared wavelengths for future all-weather systems.

PROGRESS: 8109-8207 A method of extending the memory of the correlator (i.e., extending the set of matched filters) has been developed using holographic phase screens. This process allows storage of matched filters in a 5 X 5 array, each element containing up to the order of eight superimposed matched filters. Tests have been performed on a 25 element ensemble of identical filters with parallel and individual readouts. Further work is in hand to store different reference filters at each location.

FOLLOW-UP ACTION

ORGANIZATION: MICOM Army Missile Laboratory, Redstone Ars., AL 35809

POINT OF CONTACT: Duthie, Graham, Dr. **TELEPHONE:** (205) 876-3820

SUMMARY OF DISCUSSION: If hardware utilizing this technology were fielded, it would require regular, frequent testing to correct changes or degradations in diffraction efficiency, uniformity, wavelength responses and alignment. Presently, procedures and hardware for field testing of such equipment are nonexistent, but Dr. Duthie feel that they could be developed. This is long term conjecture; it will be many years before equipment utilizing this technology is fielded.

CONCLUSION AND RECOMMENDATIONS: Test techniques and instrumentation for holographics in the IR and visible wavelengths are an area of no attention or test funding and may be a good nominee for JLC consideration.

TITLE: REAL-TIME AIRBORNE E-O CONTRAST ATTENUATION MONITOR
RDT&E CATEGORY 6.1

OBJECTIVE: AF function: ground target detection and acquisition, precision guided munitions deployment/employment, surveillance, reconnaissance. Deficiency: the capability to produce operation forecasts or climatologies of atmospheric optical contrast attenuation does not exist. Objective: to design, fabricate and test a prototype airborne sensor for the real-time determination of atmospheric contrast reduction affecting electro-optical (E-O) sensor performance. How research contributes: the proposed research, if successful, will result in a compact, rugged system, suitable for use on an RPV or similar vehicle, for making real-time determinations of contrast attenuation in denied areas for all paths of sight. This capability will give the tactical commander current information necessary for making decisions on the employment of precision guided munitions and give the planner the statistical information necessary for procurement and deployment decisions.

APPROACH: The development will proceed in two distinct phases. The first phase will build on current work being done under work unit 762111AF, to develop and validate simplified computational procedures, suitable to a real-time microprocessor environment, for obtaining contrast transmittance from measured sky and terrain radiances and aerosol scattering properties. This development will include the study of basic instrument design sensitivities and trade-offs. The second phase will consist of the engineering design, fabrication and testing of the prototype sensor package required to provide the inputs to the computational procedures. It will consist of three passive E-O transducers (two radiomenters and a nephelometer) and associated microprocessor and support assemblies. Individual component testing will be conducted by the contractor with final testing performed by the government.

PROGRESS: 810501-820430 The contract was signed on 16 June 1981. Phase one is complete and the design trade-offs have been reported in AFGL-TR-82-0125. The basic approach appears sound. The final design is nearly complete and subassembly fabrication is just beginning. No schedule problems or technical glitches are expected, but funding for FY1983 is in doubt.

FOLLOW-UP ACTION

ORGANIZATION: AF Geophysics Lab (Optics), Hanscom AFB, Bedford, MA 01730

POINT OF CONTACT: Shuttle, Eric **TELEPHONE:** (617) 861-3667

SUMMARY OF DISCUSSION: This program to measure E-O contrast attenuation has lost its funding. Test problems were not anticipated due to standard components and microprocesors (u-p).

CONCLUSION AND RECOMMENDATIONS; This should require no JLC test funding due to standard items and inherent u-p testability.

TITLE: MINIATURE ACOUSTO-OPTIC SPECTRUM ANALYZER, RDT&E CATEGORY 6.2

OBJECTIVE: The potential utility of Acousto-Optic RF Spectrum Analyzers (AOSA) in electronic warfare (EW) receiver systems is now well established. Such devices offer wide instantaneous bandwidth, high RF resolution and high probability of intercept. Until now, AOSAs have been larger than are acceptable for some applications. This is in part due to the only practical laser being a HE-NE gas laser and in part because optical components have been individually mounted and supported. Recently, semiconductor lasers have become available with performance and reliability that are satisfactory for AOSA applications. The objective of this program is to develop and demonstrate a Miniature Acousto-Optic Spectrum Analyzer (MAOSA) which combines the small size of a semiconductor laser w/innovative concepts for size reduction in optical bench design. The primary performance goals are 500 MHz bandwidth and 2 MHz RF resolution, in a volume of less than 25 cubic inches. The performance figures do not represent the expected limits of the approach but are chosen because they are readily attainable in existing Bragg cells and will provide a good test for optical design. The EW community is showing increasing interest in AOSA technology as a means for coping w/present and projected complex radar environments. The total frequency range of interest is up to about 20 GHz, but the bandwidth of an AOSA is limited to about 1-2 GHz. Thus, more than one AOSA may be desirable for each vehicle such as an F15. This consideration fosters the desire to make the AOSA as small as possible.

APPROACH: Acousto-optic (AO) spectrum analysers make use of the acoustic freqency dependence of the diffraction angle of an optical beam passed through an AO Bragg cell. An RF signal to be characterized is heterodyned to fall within the bandpass of the analyzer and applied to the acoustic transducer. The resulting acoustic waves diffract a collimated optical beam at an angle proportional to the IF. A lens focuses the diffracted light onto a detector array so that each element of the array corresponds to a discrete signal frequency. The goal of this program is to miniaturize such an acousto-optic spectrum analyzer consisting of a laser, AO bragg cell, detector array and passive optical elements. In the concept to be developed, all components from the laser through the detector array are mounted on an optically polished glass slab. After they are maneuvered to optimum position on the slab, they are fixed in position by an ultra-violet curing epoxy. The optical beam is folded several times through the slab w/prisms. This causes the geometric path length in the glass to be reduced by a factor equal to the refractive index, thus reducing the size of the device. Since the optical elements are held by epoxy rather than discrete mounting brackets, the size is further reduced. Height adjustment of the optical beam is easily

accomplished by lateral sliding of the beam folding prisms. The ease of placement of the optical elements permits the use of inexpensive components which, with the elimination of most of the

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FOLLOW-UP ACTION

ORGANIZATION: Avionics Laboratory (E-O Tech), Wright Patterson AFB, OH 45433

POINT OF CONTACT: Hamilton, Mike C. **TELEPHONE:** (513) 255-5034

SUMMARY OF DISCUSSION: In a fielded unit, inputs would be RF and output digital words; however, inside the box there would be an optical system. Problem areas might be the following: (1) laser output power measurements, (2) wavelength spread, (3) beam shape or amplitude distribution and (4) Bragg cell verifications of bandwidth and efficiency. Much testing of critical optics devices will require a laboratory environment, special equipment and skilled personnel. Field testing may not be a factor--devices may be returned to a large depot lab, or the manufacturer, or may be throw away.

CONCLUSION AND RECOMMENDATIONS: These are four good possible optical test areas which reiterate some other similar inputs. These should be taken on as possible emerging test items for JLC consideration in funding. The logistic support philosophy of these devices is critical also.

TITLE: ACOUSTO-OPTIC SIGNAL PROCESSING, RDT&E CATEGORY 6.2

OBJECTIVE: The modern-day tactical battlefield requires the rapid processing of wide bandwidth signals with large dynamic range capability for providing rapid updating of battlefield order, target acquisition, electronic warfare and signal intelligence. The program objective is development of such processors which are in addition compact, low power consuming and low cost and can process information from low-frequency audio up to microwave RF and laser radars.

APPROACH: The acousto-optic interaction, coupled together with the two technologies of Surface Acoustic-Wave (SAW) devices and integrated-optics, will be used to develop two processors of interest: triple-product convolver- wherein multiple information carrying laser beams are input upon a SAW device, with each laser beam being independently modulatable. Integrating correlator- wherein the light output of the acousto-optic interaction is focused upon an integrating diode array and the signal output is integrated for several milliseconds. The former device is used

for performing high speed discrete Fouriertransforms (DFT) and beamforming and the latter device is used for spread spectrum detection and direction finding.

PROGRESS: Compact one-dimensional time integrating correlators have been constructed. In addition, two-dimensional time integrating correlators have been formulated and demonstrated an ultra-fast Bragg cell spectrum analyzer which can follow a frequency agile signal has been constructed. The Bragg cell uses a fiber optic detector array to obtain fully parallel readout. Two detection schemes, heterodyne and intensity, were compared. The heterodyne detection scheme has higher dynamic range and superior rise time response.

FOLLOW-UP ACTION

ORGANIZATION: ERADCOM Harry Diamond Center, Adelphi, MD 20783

POINT OF CONTACT: Berg, N.J., Dr. **TELEPHONE:** (202) 394-2520

SUMMARY OF DISCUSSION: Dr. Berg feels there will be no testing acousto-optic problems in his project, even at the field level.

CONCLUSION AND RECOMMENDATIONS: All other A-O processing programs report serious speed, frequency and signal level test problems, but Dr. Berg insisted there were none even when asked more than once.

TITLE: OPTICAL SOUND GENERATION AND AMPLIFICATION, RDT&E CATEGORY 6.1

OBJECTIVE: The technical objectives are to bridge the gap between concepts of generation of sound from optical energy and operating devices, to obtain useful sound amplification from controlled excitation reactions, and to examine other analogues with wave interactions in optics for exploitation in acoustics and possible applications to Naval devices for communications, surveillance and physical measurements.

APPROACH: The processes of optical generation of sound at solid and liquid surfaces and the process of sound amplification in a vibrationally excited gas are investigated in a amplification.

FOLLOW-UP ACTION

ORGANIZATION: Office of Naval Research (Code 412), Navy Dept., Arlington, VA 22217

POINT OF CONTACT: Hargrove, Dr. TELEPHONE: (202) 696-4220

SUMMARY OF DISCUSSION: The concept of using optical energy to generate sound is very "iffy" and may not pan out. Acoustic sea laser applications are the theoretical goal. Too early to consider test methodologies. Dr. Hargrove mentioned another program too new to be in the DTIC computer output as a possible test solution for underwater sound measurement. Its title is "non-wave length limited near-field acoustic holography" and work is being done at Penn State.

CONCLUSION AND RECOMMENDATIONS: This is a very nebulous 6.1 area that needs to be followed up in a year or so for testing questions. The possible test solution is interesting.

TITLE: THIN-FILM ACOUSTO-OPTIC DEVICES, RDT&E CATEGORY (

OBJECTIVE: Solid state devices are essential components of Force electronic countermeasures, communications and signal processing systems. It is now recognized that integrated/fiber optics will have important applications in wideband multichannel communication and information processing. To achieve applications in these areas, high-performance thin film active devices are needed and thin film acousto-optic devices appear to be very promising for this purpose. The objective of this research is to investigate several thin film acousto-optical and magneto-optical devices which have potential for application systems. This effort advances optical processing for communications and information processing systems.

APPROACH: The objective will be sought through the following tasks: detailed study of novel acousto-optical device concepts and relevant device parameters, exploration of the basic phenomenon and mechanisms of guided-wave magneto-optic Bragg diffraction from magnetostatic surface waves and identification of novel applications of such devices in integrated and fiber optic systems for signal processing and communications. Basic device configuations will be used to study the underlying interaction mechanisms, to establish the key design parameters, to determine the ultimate capability of the devices and to explore unique applications.

PROGRESS: 801001-810531 A significant effort has been expended on a wideband acousto-optic Bragg cell using a tilted-finger chirp transducer. As a result of the varying width of each finger electrode, three effects have been found to be of major importance, especially as the center frequency and the bandwidth of the chirp transducer are increased. These effects are: (1) For each SAW frequency, different portions (segments) of the finger electrodes are effective. Since there is a varying step height between each adjacent segment, an unwanted steering of the acoustic phase front is created. In some situations, the steering angle is so large that the Bragg condition is totally destroyed. This effect can be

detrimental unless some means is found to compensate it. (2) Similarly, for each SAW frequency, the propagations directions of the SAW from each effective segment of the finger electrodes diverge from each other. As a result, the diffraction efficiency, the Bragg bandwidth and beam profile of the deflected spots are all affected. (3) Both electric and mass loadings of the finger electrodes may cause distortions of the phase front of the SAW generated. However, the latter is insignificant in comparison to the former for the frequency range below a few GHz.

FOLLOW-UP ACTION

ORGANIZATION: AF Office of Scientific Research (Solid State), Bldg. 410, Bolling AFB, Washington, DC 20332

POINT OF CONTACT: Neff, John A. **TELEPHONE:** (202) 767-4933

SUMMARY OF DISCUSSION: The optical processing of data or information is advancing from the GHz into the 10-12 terahertz digital processing speed. The analog data needs photo detectors. The test problem will focus on needed optical detection, and the USAF is looking into the test equipment needs. This task is investigating thin film acousto-optical and magneto-optical devices to enhance multichannel wideband applications.

CONCLUSION AND RECOMMENDATIONS: Seven very interesting R&D tasks dealing with high technology research on optical processing were followed up. They all were the responsibility of John Neff and since the comments were somewhat generic, only three of the R&D tasks will be included. Subjects of R&D tasks not enclosed were high speed bistable optical switches, analog parallel processing with fiber optic wave guides, fresnel lens and compression of image data rates with holographic matched filters. The research and test problems of optic processing fall into detection, processing and display technologies. This R&D task involves a one dimensional (ID) beam of light which simplifies the previously 2D detector array. The low level signal detection, combined with the high input data rate is a high priority test challenge.

TITLE: ELECTRON BEAM GENERATED HOLOGRAPHIC OPTICAL ELEMENT RESEARCH RDT&E CATEGORY 6.1

OBJECTIVE: AF function-future Air Force Weapons systems will require the real-time processing of data obtained from a multitude of sensors at data rates which exceed current capabilities. One promising solution embodies the parallel processing capability of optics. Opportunity-optical processors currently require complex lenses which are heavy, bulky and expensive. The proposed effort will investigate Holographic Optical

Elements (HOE) which offer advantages of a reduction in the mechanical stability problems of conventional optical systems, a reduction in the number of optical elements and reduction in weight, size and cost, all of which render these elements very applicable to the development of optical systems for aircraft and missiles. Objective: This research will explore the use of electron beam lithography for making HOEs with a large space bandwidth product. How work contributes: this effort will benefit optical processor component development for Air Force weapon systems.

APPROACH: An attempt will be made to combine the efficiency of a thick-phase hologram with the flexibility of a thin-phase hologram by taking advantage of an expertise in producing high resolution all undesired orders in a thin-phase HOE by pursuing two different techniques. One involves the use of very high spatial frequency holograms such that only the zero order and the first order satisfy the diffraction equation. The second involves blazed holographic optics which combine reflection and diffraction to produce high efficiency.

PROGRESS: 800801-810731 This research accomplished the design of a new optical computing element called a Partitioned Computer Generated Hologram (PCGH). It is an electron-beam generated diffractive mask composed of a number of linear gratings designed to deflect light to any one of a number of detectors. To reduce cross talk, it was found that the use of a number of subgratings or subfacets was more advantageous. Therefore, the diffraction pattern for a single channel is not that of a single facet, but rather is due to the aperture consisting of all subfacets for that channel. The attempt was then made to optimize the design of the total PCGH using the following considerations: subfacets for each channel should add up to the correct total intensity, subfacets for each channel should form a compact facet, facets for the dimmer channels should be located near the edges so that they may be made larger and subfacets for each channel should be located near the edges so that they may be made larger and subfacets for each channel should be balanced about the center so as to provide some immunity to beam-wander. Generally it is not possible to simultaneously satisfy each of these criteria, so a merit function was derived which aids the computer in the design of the PCGHs.

FOLLOW-UP ACTION

ORGANIZATION: AFOSR (Solid State), Bldg. 410, Bolling AFB, DC 20332

POINT OF CONTACT: Neff, John A. **TELEPHONE:** (202) 767-4933

SUMMARY OF DISCUSSION: This R&D topic is in the high speed THz 2D parallel processing optics with holographic optic elements. One result is a newly designed computer generated hologram. The high data rate, parallel channels and small optic level signals all present test challenges.

CONCLUSION AND RECOMMENDATIONS: The THz parallel channel processing will require a new generation of A[illegible] and instrumentation for all services. These optical processors will be operational in munitions, communications and ECM equipment of all platforms.

TITLE: ACOUSTO-OPTIC PROCESSING OF 2D SIGNALS, RDT&E CATEGORY 6.1

OBJECTIVE: Image processing or 2D signal processing is becoming an increasingly important part of such military systems as reconnaissance, missile guidance, target identification and tracking and space surveillance. Optical processing, with its inherent parallelism and high speed, is a leading candidate for the technology to implement real-time image processing. However, optical processors are currently severely limited by the speeds of the input modulators. The proposed research will investigate various processor architectures which employ a special arrangement of 1D acousto-optic light modulators to process 2D signals several orders of magnitude faster than current optical processors using 2D light modulators. This effort will advance optical processing for Air Force command and control systems.

APPROACH: Various processor architectures will be considered which employ, in some fashion, a combination of time integration and space integration. The factors affecting the performance of these various architectures will be investigated in terms of processing power, accuracy and realizable signal processing operations. The feasibility of such 2D acousto-optic processing will be demonstrated with an experimental processor. Investigations will be conducted into the capabilities of these processors to handle complex signals by such techniques as multi-spectral processing.

PROGRESS: None

FOLLOW-UP ACTION

ORGANIZATION: AFOSR (Solid State) Bldg. 410, Bolling AFB, Washington, DC 20332

POINT OF CONTACT: Neff, John A. **TELEPHONE:** (202) 767-4933

SUMMARY OF DISCUSSION: Various architectures for 1D light modulation to process 2D signals will be several magnitudes faster than current 2D optical processors. This is at the sensor end of the processing. The high THz data rate and optical detection problems exist for testing the processor.

CONCLUSION AND RECOMMENDATIONS: No matter what the details of the R&D task technology, the JLC must tackle the very tough high speed, low optic level test challenge presented by the next generation optic processors that will be smaller, faster and in broad applicational use.

TEST TECHNOLOGY RELATED

APPENDIX B

ASSESSMENT OF RDT&E EFFORTS
FOR
TESTING IMPACT
ON
EMERGING TECHNOLOGIES

APPENDIX B INDEX

SYSTEMS TECHNOLOGY

SYSTEMS TECHNOLOGY

TITLE: ACOUSTO-ELASTICITY THEORY AND APPLICATION, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Office of Naval Research NRL Non Special Focus Program Washington, D.C. 20375

OBJECTIVE: Determine the feasibility of using phase measurement techniques with ultrasonic waves to detect (residual) stress fields around cracks in structures.

APPROACH: An analytic study as well as a literature search will precede experimental attempts to use changes in phase velocity to measure stress fields near a crack tip. The stress field pattern will be mapped using photoelastic methods. The acoustic analog measurements of the opto-elastic methods will then be made.

PROGRESS: The literature search has been completed. Although there is some activity in this arena, the use of acoustic birefringence has not yet been fully considered. Preliminary experiments have verified the most optimistic anticipations. Stress induced changes in birefringence have been satisfactorily measured. Texture effects, due to plate rolling, have been considered and satisfactorily resolved.

TITLE: FRACTURE BEHAVIOR OF BORON ALUMINUM COMPOSITES, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Office of Scientific Research, Director of Aerospace Sciences, BLDG 410, Bolling AFB, DC 20332

OBJECTIVE: AF function-aerospace vehicle structure and propulsion system structure. Deficiency/opportunity: improved performance and durability in hostile environments require advanced structural materials. Rational use of these materials demands understanding of their properties. Objective: to understand the fracture behavior of boron-aluminum composites at room and elevated temperatures. How work contributes: provides essential knowledge which will allow the benefits of metal-matrix composites (high stiffness and strength, low weight, low thermal expansion, high temperature/severe environment stability) to be applied to aerospace systems.

APPROACH: A combined experimental and analytical effort, with concentration on crack tip damage zones, damage growth and failure modes as well as on material characterization in terms of fracture strength and microstructural properties. B-AL (5.6 mil, 6061-F) will be tested at room temperature and at 700 degrees F with a carefully selected range of flaw sizes and laminate orientations. Near-tip crack opening displacement will be measured using an interferometric displacement gage.

Damage and flaw growth will be monitored by acoustic NDE methods and studied in detail by radiography, SEM, visible light photomicrography and other methods. Results will be correlated by LEFM and energy release rate analyses. Applicability of present theoretical results will be assessed.

PROGRESS : 800601-810430 Fracture processes in metal matrix composite materials are unique because of the combination of a highly ductile matrix material with very brittle reinforcing fibers. The primary objective of this research is to develop an experimental methodology for characterizing fracture in metal matrix composites. Boron/aluminum-6061F is the material selected for study due to its extensive use availability and established property data base. Mode-1 fracture of thin laminates with a central notch has been studied at room and elevated temperatures for (0) and (90) ply layups. The investigation focused on four main areas: (1) experimental setup, technique and instrumentation; (2) correlation of findings with existing prediction methods; (3) damage detection and (4) failure characterization. A unique feature of the experimental approach is the measurement of local crack opening displacements with a laser interferometric displacement gage. Several significant findings have emerged. Elevated temperature effects significantly alter local material response near the notch, although overall fiber direction strength and stiffness are unaffected by tempratures up to 600 degrees F. No fiber pullout has been found, although matrix fracture around fibers occurs. Fiber-matrix interface bonds remain intact up to 600 degrees F. Local crack opening compliance is a sensitive parameter which suggests further development of the laser interferometric measurement system will be fruitful.

TITLE: PHOTOACOUSTIC MICROSCOPY 18886-MS, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: DARCOM Army Research Office, Durham, NC 27709

OBJECTIVE: To extend research on Scanning Photo Acoustic Microscopy (SPAM) for studies of flaws such as microcracks relating to fatigue and high temperature fracture and to defects in semiconductor materials. Relevance. The research is relevant to a host of diverse Army NDE applications from tank track pads to the adiabatic diesel engine and to integrated circuits.

APPROACH: The research will include (1) use of SPAM for quantitative NDE of subsurface crack growth at high temperatures in ceramics. (2) The details of crack opening in fatigue of aluminum and titanium alloys. (3) The relative merits of detection and characterization by CW phase and time domain information. (4) Other engineering materials of interest to the Army. (5) The utilization of particle beams (from SEM or proton beams from a particle accelerator) as the source of thermal waves.

PROGRESS: None to report.

TITLE: EMC MIL STANDARDS and SPECIFICATIONS R&D SUPPORT, RDT&E CATEGORY

RESPONSIBLE DOD ORGANIZATION: CECOM Communications Systems Center, ATTN: DRSEL-COM, Ft. Monmouth, NJ 07703

OBJECTIVE: Participate in the joint planning and development of a complete range of up-to-date electromagnetic compatibility standards and specifications for design, development, procurement, production, test and measurement of components, units, equipments, subsystems, sysems, and complete environments as relating to electromagnetic compatibility or electromagnetic interference.

APPROACH: Conduct internal R&D efforts to support the assignments given to the Army as part of the overall DOD EMC Standards and specification plan. Draft documents will be prepared as required and submitted to the DOD EMC standards and specification working group.

PROGRESS: 8012-8112 - Army representation on IRAC ubcommittee on standards; membership on national standardization committees in the areas of susceptibility testing and equipment parameter measurements. Ar y member on CCIR study group on spectrum utilization and part of US delegation to 1978-1982 study period final meeting. Completed effort to evaluate radiated emission and susceptibility measurement techniques.

TITLE: EVALUATION OF NDE EXPERIMENTAL TECHNIQUES, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Office of Naval Research (474), code 432

OBJECTIVE: A prime intention of this effort is to discern which non destructive evaluation (NDE) techniques can be used with some confidence to detect imminent structural failure. Such techniques, if developed, would be of great value to Naval engineers and scientist in determining the useful life of a structural system.

APPROACH: Four NDE methods have been studied including the following: (1) frequency monitoring, (2) internal friction, (3) random decrement and (4) acoustic emissions. All four methods are being examined in the context of a series of tests which have been conducted on a prototype structure representative of an offshore platform. Based on the predictive capability of these different techniques to discern the structural integrity of a partially damaged structure, the relative merits of these approaches will be objectively evaluated.

PROGRESS: A series of tests have been completed on an offshore structure prototype as well as a larger scale so-called K Joint Section. Experimental data representing the intact structure was provided to

advocates of the various approaches. A series of tests was also conducted on the structure with selected damages which are to be discerned by the advocates in light of the methodology which they are recommending. Another alternate technique is utilizing low frequency ultrasonics to attempt to obtain a much larger radius of action than with conventional ultrasonic procedures.

TITLE: NDT OF SEMICONDUCTORS USING SURFACE ACOUSTIC WAVE, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: AF Office of Scientific Research Dir of Elect/Solid State Sciences, BLDG 410, Bolling AFB, DC 20332

OBJECTIVE: Improved reliability, economy and increased mean-time-between-failures is needed for advanced Air Force command, control, communication reconnaissance and surveillance systems. Semiconductors used in these systems cannot be fully tested during manufacture because no good non-destructive methods exist to inspect the starting material or the devices during the manufacturing phase. This situation requires that semiconductor devices be made in large batches and inspected for function using time consuming testing methods after circuit manufacture. Inspecting after completing the manufacture of the electronic devices leads to throwing away 20 to 80 percent of the completed devices and to lack of knowledge of what causes their failures, since subsequent processing often destroys or buries the initiating flaw. The objective of the proposed research is to develop the technological methods to perform non-contact, non-destructive evaluation of III-V semiconductor materials, advanced semiconductor devices and in situ laser annealing processes using surface acoustic wave techniques. There are numerous methods for characterizing semiconductors, but the techniques are restricted or destructive. Characterization of semiconductors using SAWS is non-destructive and can be performed at progressive stages of device fabrication thereby improving yield by identifying faulty processing steps. The technique also allows in situ monitoring of impurity activation in laser annealing of ion implanted samples. Imaging impurity locations makes the techniques even more versatile, as this gives the diagnostic measurement by all available imaging and non-imaging techniques.

APPROACH: RPI's principle investigator, professor P.K. Das, has proposed using surface acoustic waves (SAW) to generate evanescent fields above the SAW substrate. These fields probe the semiconductor wafer under test and allow non-contact measurements of the surface conductivity, the level of dopant, and the presence of electrical imperfections. This renewal continues this effort and the effort to combine scanning imaging techniques with the SAW inspection methods as well as the continuation of the theoretical modeling efforts. The models and the imaging will be tested on Gallium Arsenide, Indium Phosphide and other semiconductors. The method can determine trap locations, surface

and interface states, bulk and surface conductivity and mobility and trap lifetimes by studying the attenuated output and transverse acoustic-electric voltage in the presence of applied DC bias and different light wavelengths illuminating the semiconductor.

PROGRESS: None

TITLE: HETERADYNE HOLOGRAPHY FOR VIBRATION ANALYSIS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: AERO Propulsion Laboratory (AFWAL/PO) Component Branch, Wright-Patterson AFB, Ohio 45433

OBJECTIVE: The objective of this program is the quantitative determination of surface strain of turbine engine bleeding subjected to steady-state vibration.

APPROACH: Develop an opta-electronic system to increase the sensitivity and accuracy of using holographic fringes to compute surface strain.

PROGRESS: None

TITLE: DIFFERENTIAL PRESSURE TRANSDUCER DEVELOPMENT, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Naval Air Propulsion Center Research and Technology Group, Trenton, NJ 08628

OBJECTIVE: The principal objective of this effort is to develop and demonstrate a high accuracy differential pressure transducer, designed to sense the fan discharge mach number in an advanced military aircraft gas turbine engine and to be used in conjunction with advanced digital electronic fuel controls. The accuracy goal is 1 percent of point over a range of 0.25 to 25.0 PSI differential at absolute pressure levels of 2 to 100 PSIA. The reliability goal is 100,000 hours MTBF. The response goal is a system time constant less than 20 milliseconds.

APPROACH: This effort will design, fabricate and test a miniaturized vibrating cylinder pressure transducer. Design optimization for size will be followed by two hardware iterations with breadboard testing. The finalized sensor will undergo performance and environmental testing followed by delivery of two units to NAPC.

PROGRESS: Period 8003 through 8009. The second transducer was delivered to NAPC in satisfactory condition. The final draft report was approved and publication authorized. This action completes this work unit.

TITLE: COMBAT MAINTENANCE CONCEPTS FOR ARMY HELICOPTERS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: AVRADCOM Applied Technology Lab, FT. Eustis, VA 23604

OBJECTIVE: To develop inspection criteria, repair techniques, maintenance support concepts and a design methodology that will permit greater repairability/deferrability of combat damage to reduce maintenance downtime of Army helicopters.

APPROACH: Formulate and manage in-house and contractual efforts to meet the above objective. In-house efforts include preparation and processing of Determination and Findings (D&F) and Statements of Work (SOW) for contractual efforts, conduct of in-house projects to develop and evaluate inspection and repair concepts for helicopter components. Supporting the in-house effort will be contractual efforts to develop specific inspection criteria and evaluate repair concepts for helicopter structural damage. Also, all scheduled and unscheduled maintenance requirements will be critically reviewed to provide the basis to recommend changes to maintenance policy and procedures to minimize maintenance down-time. Coordinate and participate in efforts related to combat maintenance with Army, Air Force and Navy agencies and with the services of allied governments.

PROGRESS: The contracts were awarded in FY79. One contractual effort, awarded to Rayche Corporation, will determine the feasibility of using shape memory alloys to repair fluid lines, control tubes and tail rotor drive shafts. Two parallel contracts were awarded to develop inspection and field repair concepts for combat damage to helicopter structures. Under a contract, Kaman Aerospace Corporation will analyze the AH-IS airframe, and under the second contract, Sikorsky Aircraft will analyze the UH-60A airframe. All contractors have submitted interim reports and scheduled completions of these contracts was the end of FY1980. 8007-8107: Contract DAAK51-79-C-0048 (KAMAN) and DAAK51-79-C-0049 (Sikorsky) both titled combat maintenance concepts and repair techniques (Structures) have been completed and final reports published. The Kaman report number is USAAVRADCOM-TR-80-D 40 and the Sikorsky report number is USAAVRADCOM-TR-81-D-4. The RFP for the follow-on effort structures inspection and repair concepts were issued in August 1981. RFP for wiring inspection and repair concepts has been issued and proposals have been received. The objective of this program is to analyze helicopter battle damage wiring inspection and repair techniques, identify problems associated with current techniques and procedures and to identify inspection and repair procedures and equipment that would permit rapid assessment and repair of same at the lowest possible level of maintenance. Contract DAAK51-79-C-0059 combat maintenance concepts and repair techniques (fluid lines, control tubes, drive shafts) has been

modified to procure Shape Me ory Alloy (SMA) repair couplings for in-house test program. The full-ring coupling design has successfully completed the test program under the subject contract and currently are being fabricated under the curent contract modification.

TITLE; MISSILE TECHNOLOGY AUTOMATIC TEST EQUIPMENT, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: MIRADCOM Ground Equip & Mic Structure, Dir., Redstone AR., AL 35809

OBJECTIVE: Analyze and define industrial/government state-of-the-art in Automatic Tert Equipment (ATE) design, as pertains to ATE for missile systems. Evaluate design criteria and determine how BITE can be used to improve system design. Prepare design guide to be used by the developers of future Army missile systems. Design power supply using design guide. Design, fabricate and test an integrated built-in-test control unit to monitor critical subsystem parameters during system operations.

APPROACH: Contractor shall evaluate representative MICOM i ile systems and identify those systems recommended for subsequent development of test requirements analyses. For i--ile systems chosen, evaluate the design criteria and determine how BITE could be used to improve the system design. Prepare a BIT/BITE design guide. Design hardware using BIT/BITE design guide. A BIT control unit will be designed, fabricated, tested and integrated into a selected missile control sybsystem to provide a functional integrity test of missile hardware at times of turn on and will provide continuous monitoring of subsystem criteria parameters during operation of missile control subsystems.

PROGRESS: 8107-8111: The power supply has been modified with test point and control switches, 400 cycle power source procured, voice synthesizer integrated into the system, and control hardware delivered and integrated. Software tools have been ordered for the control system software development.

TITLE: TROUBLESHOOTING PROCEDURES SNEAK CIRCUIT ANALYSIS, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: AF Human Resources Laboratory Logistics Research Branch, Brook- AFB, Texas 78235

OBJECTIVE: Air Force function: this effort supports R&D for technical data development. Deficiency or opportunity: sneak circuit analysis, when available, has the potential of aiding in the development of fault isolation procedures. A procedure for utilization of this data does not exist. Objective: a procedure to utilize sneak circuit analysis

products as a basis for fault isolation procedures. How work contributes: Technical writers will be able to utilize data developed under sneak circuit analysis as an additional information source. This secondary use of the data will make the analysis more cost effective.

APPROACH: The contract effort will be eight months in duration. The first month will be the data acquisition phase. Files will be established for maintenance information, test equipment availability information, system configuration and operational data and the current configuration in network tree format. This information will be government-furnished. The second and third month will be spent in analyzing the network trees and development of fault isolation procedures. The fourth month will be spent in formatting the network trees and logic diagrams, modifying the output for purposes of ease of understanding and effectiveness and informally documenting the study. The fifth month will be for a limited field test, review and comments. The remaining period will be for technical report preparation and submittal. Milestones: Contract start, 1 February 81, contract end, 30 September 81, work unit complete, 31 December 81.

PROGRESS: 810513-810915 A contract for this effort has been awarded, effective 1 May 81, to the Boeing Aerospace Company, Houston, TX. The field test portion of the effort was deleted through the contract negotiation process. Due to the contract requirement of only two trips to Wright-Patterson AFB by contractor personnel, the kick-off eeting was conducted via telephone. Items of the kick-off meeting included contractor travel, contractor technical data needs and milestones. To date, the contractor has completed the following task: (1) data acquisition, (2) analysis of the network trees, (3) development of fault isolation procedures, (4) format network trees and (5) format logic diagrams.

TITLE: ANALYTICAL PROCEDURES FOR TESTABILITY, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: A comprehensive survey of the field of equipment diagnostic design resulted in the finding that with one exception, optimization techniques and algorithms for the design of diagnostics (fault detection, isolation) are either too simplistic (and naive) for application or nonexistent. It has also been found that the modeling of test system effectiveness is in its infancy, both for the effectiveness of a single test unit and, more importantly, for composite test systems, taking into account combinations of organizational built-in-test, external organization test, shop test and depot test. It is evident that more research must be devoted to the development of analytical procedures and algorithms to aid in the design (or to develop optimum designs) of fault

isolation and detection subsystems. It is clear that without such models, visibility of the relationships among testability, acquisition cost, logistics and support costs, various measures of system and logistics support effectiveness are not possible (and meaningful trade-offs among the test system parameters and cost effectiveness, etc., are not possible). We have now reached the point where we must address the development of analytical tools and methodologies of the type addressed above to develop a more refined quantitative foundation.

APPROACH: Application of system engineering, operations research, modeling procedures coupled with a strong electronic engineering base to the problems at hand. Effort should start with a thorough review of the literature in various scientific fields to determine whether or not techniques and models developed for other purposes can be applied to our need with proper modifications.

PROGRESS: None

TITLE: REL/TEST/DESIGN FOR FAULT TOLERANT SYSTEM, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of the effort is to investigate and develop reliability, testability and application guidance relative to fault tolerant systems. The effort shall take into account both current technology and projected future technology and shall specifically address distributed systems. Both software and hardware characteristics shall be taken into account in defining reliability and testability (fault isolation, detection, performance monitoring). The problems of testability in distributed systems, such as PAVE PAWS, COBRA DANE, DEWLINE and the integrated C3 for TAC, will be addressed. In addition, the investigation shall include the consideration of using microprocessors in the design, configuration and control and both software and hardware fault tolerant design techniques.

APPROACH: The contractor must collect and analyze information and data relative to (1) The range of systems and complexities of such systems to which fault tolerance can be applied. (2) Current and near future technologies which can be exploited to implement fault tolerance. (3) The problems which may be encountered with current fault tolerant systems (i.e., performance monitoring fault isolation, fault detection). (4) Investigation of possible solutions to such problems. The conclusions drawn from such an analysis shall define the scope, advantages and disadvantages of fault tolerance and provide possible solutions to current problems in the area.

PROGRESS: None

TITLE: FAILURE MODES AND EFFECTS ANALYSIS METHOLOGY, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: Presently, Failure Modes and Effects Analyses (FMEAs) are called out in every DOD equipment/system procurement. Yet, there is no guidance available as to the various levels at which it can be applied (system, LRU, piece part, etc.) and no techniques available to implement its accomplishment at each level. At the same time, the results of the FMEA'S are finding more uses such as built-in-test and external test system design. In addition, an FMEA is called out in reliability, maintainability, criticality, and safety analyses standards and optimum repair level analyses. The objective of this effort shall be to investigate the very limited guidance that is available to anyone performing an FMEA, develop practical FMEA techniques appropriate to the various levels of system indenture and provide guidance as to their application. Such guidelines shall also include estimates of the costs necessary to perform an FMEA to various levels.

APPROACH: This effort shall require the contractor to analyze the desired uses of the results of an FMEA, survey what guidance is presently available for conducting an FMEA, and develop practical procedures for performing an FMEA at various levels of system indenture.

PROGRESS: 800303-810227 A review of documents that contain procedures for FMEAS has been completed and usable portions have been extracted. The relationship between FMEA and other design activities (i.e., reliability analyses, safety analyses, test subsystem analyses, etc.) has been documented. A simplified FMEA procedure has been developed that elimlinates the duplication of effort involved in performing the FMEA, tne system safety analysis and the FMEA, but includes the major elements of all three. Appropriate worksheets to be used in conjunction with this procedure have also been developed.

TITLE: STUDY OF CAUSES OF UNNECESSARY REMOVALS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: Recent inquiries made by RADC of both government and industrial repair facilities indicate that up to 40 percent of the items (LRUs, SRUs, etc.) that are removed from electronic equipment for repairs of suspected failures test "good" when repair is attempted. Reasons for this result are attributed (with little hard evidence) to the inability to reproduce the actual use environments, presence of intermittent failures or the inability of built-in-test or external test subsystems to correctly indicate a failure. Whatever the reason(s), an enormous amount of manpower and money is being wasted due to such

occurrences. The objective of this effort will be to investigate what are the actual causes for these needless removals and to determine possible means to minimize them while not adversely affecting the basic mission effectiveness of the electronic equipment.

APPROACH: This program requires the contractor to verify the problem, collect data and, to the degree necessary, monitor selected field and repair facilities to verify the causes and the relative frequency of occurrence of each cause. After such evidence is compiled, means and plans of attack will be formulated to either eliminate or minimlize the base causes.

PROGRESS: 811006-820504 Establishing a logical and repetitive trail of formulating the causes of unnecessary removals from the data collected has been the area of concentration during this time period. Combining the 'when discovered' data with the field survey inputs has yielded a viable trial of data to causes and has been documented. The variablity of the percentage of unnecessary removals from base to base has also been studied and found to vary significantly (i.e., two bases involving the same equipment on the same aircraft varied from 0 percent to 80 percent).

TITLE: IMPROVED STATIC MEASUREMENT CAPABILITY, RDT&E CATEGORY 0

RESPONSIBLE DOD ORGANIZATION: 6585/Test/Group/Guidance Test Division, Holloman Air Force Base, NM 88330

OBJECTIVE: This task is to provide a stable/predictable test bed environment for static testing of precision navigation systems and components. Significant improvement in our environmental control and measurement accuracies are required to keep pace with improvements in the capabilities of test specimens. To maintain the level of technical evaluation service that we have typically provided our customers in the past, improvements are necessary in the following areas: stable platforms, azimuth motion sensors, seismometers, tiltmeters, autocollimators, and other environmental controllers and sensors.
PROGRESS: New effort

TITLE: NAVIGATION: STORED ION SPECTROSCOPY FREQUENCY STANDARD RDT&E CATEGORY

RESPONSIBLE DOD ORGANIZATION: Office of Naval Research Department of the Navy (421), Arlington, VA 22217

OBJECTIVE: Stored ion spectroscopy may provide a means of improving and simplifying highly accurate timing devices. Accurate timing is of interest to the Navy through improved positioning and missile accuracy. It may also be of importance in the areas of rapid transmission of digital data and long base line interferometry.

APPROACH: A new stored ion system based on HG (201) plus ions is being constructed. Laser cooling studies of a single ion in a trap are being performed to make a direct comparison between experiment and theoretical predictions. Studies of an apparent condensation phenomenon when a group of ions are cooled are continuing.

PROGRESS: Double resonance experiments have been performed on a single trapped MG(24) plus ion. Linewidths of 0.012 Hz have been observed for MG(25) plus ions. The previous theoretical cooling treatment of laser cooling in harmonic traps has been extended to a penning trap. ('Spectroscopy of a single MG plus ion', D.J. Wineland and Wayne M. Itano, Phys. Lett. 82A, 75 (1981).)

TITLE: OC SURVEILLANCE LAB, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Techniques Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of the OC Surveillance Laboratory (OCSL) is to provide a test facility which will cover the frequency range from L-band (1200 MHz) through X-band (10,000 MHz) to provide TAC with data to write specifications for their advanced radars in the 1985-95 time frame. It will provide a programmable multifunctional adaptive surveillance capability to meet these future TAC requirements as well as maximizing the utilization of available manpower and funds.

APPROACH: All of the OC laboratories will be consolidated in corridor F of building 106 at RADC and from the OCSL. These include the Signal Processing Laboratory (SPL), Tactical Target Identification (TTI), Radar Simulation (RADSM), Video Processing Laboratory (VPL), Optical Platform for Testing Control Algorithms (OPTECAL), Forward Area Command Post (FACP). The SPL presently has a L-band radar in operation; a S-band radar system is now is the process of being contructed, utilizing both contractual and in-house efforts. The C-band phased array radar system went out for bid in FY81 with equipment delivery scheduled for FY83. The SPL will be the nucleus of the OCSL and will provide all the waveform generation, timing, data storage and analysis for all the radar systems.

PROGRESS: 811102-820524 The bids for the physical expansion of the OC surveillance laboratory have been received. An anticipated date for the contract signing was in the second week of June 82. This was to be a six month effort which put the completion date in December 82. The scheduled move into the new facilities was January 83. The S-band dual tracking system is nearing completion. Minor problems in pressurizing and arcing in the waveguide have caused some delay, however, these are now being corrected. The angle tracker and range tracker, which are being designed and constructed in-house, are on schedule and will be available in the

July time frame for testing. The Electronic Systems Measurement (ESM) equipment has been installed in the laboratory and is now operational. This equipment uses the TPX-42 IFF and the Programmable Indicator Data Processor (PIDP) air traffic control system with specialized algorithms for passive aircraft identification.

TITLE: ADVANCED PCB TESTABILITY, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: The result of a recent RADC testability effort, 'An Objective PCB Testability Design And Rating Syste ', contract F30602-78-C-0198, yielded a printed circuit board (PCB) testability evaluation/rating procedure. This procedure is gaining acceptance from industry and is currently being used on DOD contracts. The objective of this FY81 effort was to expand the methodology derived in the previous study for application to the module, equipment and subsystem level. Specifically, the PCB rating procedure would provide the nucleus of a basic building block approach to assess the testability of higher system indenture levels. This would result in the development of a testability evaluation/prediction concept, akin to the part failure rate concept used to determine system reliability.

APPROACH: A survey should be performed of recently developed electronic systems and those in the design stage. A variety of PCBs, modules and subsystems should be selected from these systems and used as test vehicles for an initial testability analysis/evaluation, using the PCB testability rating procedure. Also, the PCBs, modules, subsystems comprising a complete system should be analyzed/evaluated in various combinations, using the PCB testability rating procedure, to determine the impact of individual unit testability ratings on the overall system testability. This would provide pertinent design for testability data and trade-off considerations and lead to the development of a system testability design and evaluation tool.

PROGRESS: None

TITLE: DEVELOPMENT OF A TESTABILITY NOTEBOOK, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Engineering Branch, Griffiss AFB, NY 13441

OBJECTIVE: Over the past several years, RADC and others have investigated the various facets of testability and developed some useful tools. What is required at this time is an organized compilation of these efforts into a single document. This document would treat testability on cradle-to-grave basis, indicating what should be

accomplished (and to what extent) in the various phases of the acquisition process and in operational and maintenance planning. The final product will be a 'how to' document and will be useful to both government and industry and will also serve to describe the interface between testability and maintainability and ATE efforts.

APPROACH: (1) Determine the exact format and content of an effective testability design notebook, (2) perform a survey of DOD and industry to determine what is available in the areas of testability and couple the information with the result of RBRT's current programs in testability, (3) organize the information collected into a logical sequence and (4) fill in and/or identify any voids apparent.

PROGRESS: 791228-800918. Notebook format is complete. Data collection is continuing. Data collected being analyzed and assembled to conform with the notebook format.

COMPONENTS TECHNOLOGY

TITLE: ELECTRICAL TEST AND EVALUATION OF MICROCIRCUITS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

OBJECTIVE: To maintain an in-house microcircuit test and evaluation laboratory capable of performing complete and detailed electrical measurement characterization on all state-of-the-art microelectronic devices. This capability is used to provide direct support to other in-house programs as well as other requesting agencies for the study of microcircuit reliability, electrical testing and specification problems. Some direct electrical test and evaluation effort is included in this project to study major electrical test implementation problems associated with specific high interest devices families, such as complex LSI microprocessors. Also, some direct effort is for the evaluation of techniques used for the measurement of microcircuit performance on automated test equipment. The majority of the activity is required to provide for equipment acquisition, maintenance, calibration, facility management and system file maintenance for the S-3260 automated microcircuit test system.

APPROACH: Maintenance contracts will be established with both the manufacturer of the controller equipment and the manufacturer of the testing equipment to provide for rapid repair of major equipment malfunctions. In addition, spare parts are to be maintained to provide rapid in-house repair of routine problems. Expendable items such as sockets, wire, hardware interface adaptors, paper, tapes, electronic components, etc., are ordered and stocked at a level that will permit timely response to the majority of the microcircuit testing requirements encountered. The equipment is constantly updated as new testing requirements are established consistent with the availability of the required capabilities. Equipment calibration is verified daily and prior to any critical testing to ensure measurement accuracy. System data analysis and reduction routines are constantly developed and expanded to accommodate most common requirements. The S-3260 automated test system capability will be periodically upgraded to meet all projected testing requirements. Routine daily file maintenance procedures will be performed to ensure backup copies of all critical files are generated and to ensure accessibility and visibility into all available programming. Testing hardware shall be cataloged to prevent unnecessary hardware duplication and both standard MIL-M-38510 testing programs and nonstandard evaluation programs shall be identified in cross reference listings to easily verify test program availability. Testing programs will be implemented and verified for the majority of the MIL-M-38510

microprocessor devices and their support chips as the specific slash sheets become available. Testing programs, test pattern vector sets and relevant descriptive information will be made available to users as specific testing programs are generated.

PROGRESS: 811005-820427 training of two new engineers has been completed and they are

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TITLE: MANUFACTURING FOR RF POWER AMPLIFIERS, RDT&E CATEGORY OPN

RESPONSIBLE DOD ORGANIZATION: Naval Air Systems Command Tech Ad in (Equip and Support), Washington DC

OBJECTIVE: The objective of this task is to institute improvements in the assembly, electrical test and reliability processing of miniaturized broadband solid state RF power amplifiers and their subassemblies for the AN/ARC-182, AN/ARC-159 and other Navy radio programs that will improve product producibility and reliability at a major reduction in cost.

APPROACH: Apply improved technology to critical manufacturing steps which will reduce manufacturing time, operator skill requirements, component/ odule failure and cost. Specific improvements will include automated component, subassembly and module testing, automated assembly and wire bonding, improved soldering techniques, improved circuit layout and partitioning, improved packaging is also being performed under contracts reported on work unit.

PROGRESS: July 80-December 80, A procurement package and work statement in preparation for the contract have been initiated.

TITLE: A MICROELECTRONICS DESIGN FACILITY, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: DARCOM Army Research Office, Durham, RSCH TRI PK NC 27709

OBJECTIVE: To conduct research in microelectronics circuits and systems especially in computer-aided design and computer engineering. Relevance. The Army requires custom VLSI circuits to obtain maximum utilization of VLSI technology. Computer architectures for implementation in VLSI will enhance system design for utilization of the DOD language of ADA.

APPROACH: To provide equipment to enable the investigation of computer-aided design for custom VLSI circuits including techniques for layout, design rule checking and simulation; the incorporation of

testing circuits, redundancy and standard cells in VLSI design; and the development of signal processing and computer architectures for implementation in VLSI.

PROGRESS: None to report

TITLE: FAULT TOLERANT VSLI DESIGN ASSESSMENTS FOR ADVANCED AVIONIC APPLICATIONS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: AF Office of Scientific Research DIR of Elect/Solid State Sciences, BLDG 410, Bolling AFB, DC 20332

OBJECTIVE: The objective of this research effort is to devise and assess fault tolerant VLSI circuit designs for advanced avionic applications. The trend toward very large scale integrated circuit design is projected to be costly in terms of development, fabrication yield, application reliability and testability. To enhance the competitiveness of VLSI circuitry, means must be provided to analyze and hopefully circumvent these limitations. One approach is through redundancy techniques applied in various functional and operational ways that begin at the circuit fabrication levels.

APPROACH: The approach to be pursued is to apply duplicate subcircuits in association with fault detection, isolation and corrective analysis so that some useful semblance of the circuit application can be maintained. The results will be compared with the economic feasibility to develop and apply these more complex circuits.

PROGRESS: None

TITLE: ACQUISITION OF ELECTRICAL CHARACTERIZATION, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

OBJECTIVE: This effort supports the electrical characterization program and is intended to accelerate the availability of special electrical test and design data from prospective sources for military qualified QPL LSI/Microprocessor.

APPROACH: The data, resulting from the program will be in two forms: (1) engineering design data, including schematics, topology layouts and logic designs and (2) electrical test data performed at vendor's facilities utilizing functional test procedures contained in proposed military specifications. The end product of this effort will be 20 test reports that can be utilized to accelerate the development of military specifications concerning LSI/Microprocessor.

PROGRESS: None

TITLE: ADV ELEC TEST TECH FOR LSI MICROCIRCUITS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of this effort will be to determine, for specific LSI microcircuit part types, what externally measurable characteristics are sensitive indicators of internal structure quality and ultimate device reliability. This requires identification of internal characteristics related to localized chip quality, which are capable of being measured using the external pins. These characteristics should be measurable on as many different chip locations as possible. For semiconductor memories, individual cell access time, refresh time, minimum data retention voltage, etc., represent such externally measurable parameters related to specific different internal locations. All internal locations would be measured for the identified characteristics and plots made showing the value of the measured characteristics as a function of the number of locations having that value (similar to a histogram or shmoo plot). On a good device a well defined characteristic would be expected. If an internal location or combination of locations had a physical abnormality which could affect the measured characteristic, such as a pinhole near a junction, or surface inversion, etc., there would be some deviation from expected data distributions. Depending on the nature of measurements obtained from these deviant locations, the appearance of an abnormal distribution could corrrelate with future reliability problems for that device. In addition to device-to-device anomalies, lot-to-lot process variations should also be observable. By evaluating the effectiveness of these electrical measurement techniques on LSI test vehicles, it should be possible to identify any potential gain in device reliability or improved operating margins if specific tests were to be included as required MIL-M-38510 test procedures.

APPROACH: This effort shall determine the effectiveness of using internally measured characteristics related to component physical properties for the identification of complex microcircuit reliability problems if implemented as an electrical screen test. This concept, which has been used to some extent for characterization application, will be evaluated for possible use as either a general or detailed test method. The specific work will include (1) identify existing concepts and development of new elecrical test techniques which will yield information on internal component quality from a semiconductor physics approach; (2) implement all identified test vehicles representative of two different LSI technologies; (3) implement all identified test on automated test equipment and evaluate using statistical and graphpical techniques; (4) assess the significance, relevance, advantages and disadvantages of all identified tests as compared to existing test

procedures; (5) perform short term life tests to identify any possible correlation between initial measurement characteristics and observed drift mechanisms, device degradation or failure; (6) assess trade-off considerations between conventional testing techniques and techniques considered on this effort.

TITLE: DIGITAL IC-MACROMODELING APPROACH, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Compatibility Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of this effort is to add funds to contract (F30602-78-C-0083) in the amount of 45K to initiate a post doctoral effort with the electrical and computer engineering department of Syracuse University to perform research in the area of macromodeling digital integrated circuits.

APPROACH: With the increasing use of large scale and very large scale integrated circuits (LSI, VLSI), it has become more costly and increasingly difficult to perform EMC analysis and prediction. Therefore, it is advantageous to model various high complexity solid state devices in terms of smaller equipment circuit subunits, thereby reducing the costly simulation runs. This approach, called macromodeling, has been successfully employed in generating simple circuit models for small scale linear, analog integrated circuits (e.g., cascade amplifiers, operational amplifiers). This program would extend this modeling concept to include digital device functions (e.g., gates, flip-flops, memories, etc.). This in turn would provide the basis for EMC analysis of evolving high density integrated circuits. It is desirable to develop macromodeling techniques and concepts for simple digital integrated logic circuits. In this way, simpler models can be combined in an effort model to arrive at the electromagnetic compatibility performance of sophisticated digital equipment.

PROGRESS: None

TITLE: CHARACTER OF MAGNETIC BUBBLE MEMORY (MBM), RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

APPROACH: MBM devices will be electrically characterized according to their switching, DC, and functional parameters. The characterization will be conducted over the full military temperature range, or what is determined to be the device's maximum functional range. MIL STD-883 test methods, when applicable, shall be used for testing individual parameters. Special tests such as coil drive, bias margin and data retention will be evaluated using existing criteria.

PROGRESS: 820301-820503 General Electric is modifying their S3270 automatic tester to accommodate the special requirements of MBM devices. At present, the sense amplifier, which provides enough gain on the detector signal for adequate measuement, has been completed and interfaced to a waveform digitizer. The under socket card assembly, which provides the coil drivers and function drivers, is 90 percent complete. When this modification is complete, GE will begin characterization of the INTEL 7110. A detailed test plan for performing this characterization has been developed.

TITLE: ELEC. TEST AND ANALYSIS OF LINEAR MICROCIRCUITS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of this in-house program is to test and analyze high military usage analog functional microcircuits for the purpose of inclusion in the MIL-M-38510 slash sheets. This is a continuation of a previous effort, electrical characterization of analog switches/multiplexers (JON 23380172).

APPROACH: Electrical test procedures will be developed for the 6.1 program on optical materials and components involving the strengthening characterization of various analog microcircuits. Device parametric test limits will then be determined; work will also be done to increase in-house test capabilities for these microcircuits.

PROGRESS: 810901-820430 In-house characterization of the analog multiplier/divider microcircuits (KAD 532,534) has culminated with a draft slash sheet which will be sent for industry and tri-service coordination. Evaluation and tri-service coordination of the revision for /190 (analog multiplexers) was completed. This new document /190A will be released this summer. The 2920 signal processor and the 1525 with modulator microcircuits are undergoing preliminary evaluation.

TITLE: AUTO TEST METHODS FOR LINEAR MICRO CIRCUITS RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Reliability Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of this effort is to review MIL-M-38510 operational amplifier (opamp) and comparator electrical test conditions and MIL-STD-883 test procedures. There is a weakness in these electrical specifications in that several of the measurements are not directly amenable to automatic testing procedures. This will be an attempt to simplify the testing of these parts in an automated testing environment

with emphasis on gain measurements. Other measurements that must be reviewed include, but are not limited to, input voltage, output voltage risetime, settling time and overshoot, noise and output short circuit current. In addition to focusing on each measurement individually, their effects on each other shall be studied in view of the speed and sequence of the tests on automatic test equipment (ATE). The results of this work will be used to improve MIL-M-38510 electrical specifications and MIL-STD-883 test methods in an effort to increase the accuracy and repeatability of the measurements necessary to evaluate the performance and reliability of amps and comparators.

APPROACH: (1) Obtain commercial operational amplifier and comparators to be used as test vehicles for evaluating the corresponding MIL-M-38510 specification. (2) Study gain characteristics of each device as well as the presently specified method of measuring gain. Evaluate gain measurement techniques that are more accurate and amenable to automatic test procedures. (3) Study selected operational amplifier and comparator parameters to determine the accuracies of the measurements done in rapid succession on ATE. (4) Prepare a list of recommendations associated with each measurement as necessary which can be used as a guide for the improvement and preparation of microcircuit specifications.

PROGRESS: 810727-820427 This effort addressed the testing of specific linear device types using general purpose digital automated test equipment (ATE). The specific device types used as test vehicles included the M-38510/10104, 10107, 11901 (LM108A, LM118, TL061) operational amplifiers and the M-38510/10304 (LM111) comparator. Interface adapters and test procedures were evaluated to determine the test repeatability and accuracy that could be obtained using various approaches and comparing to bench test methods. Alternative testing techniques that eliminate the null amplifier used in the MIL-M-38510 approach and take advantage of the iterative power of ATE were evaluated. Especially difficult tests such as current measurements in the picoampere range and AC measurements such as rise time, overshoot, settling time and slew rate were evaluated to determine the best possible implementation. Most of the techniques evaluated to determine the best possible implementation. Most of the techniques evaluated attempt to improve accuracy and repeatability; however, at the expense of a considerable increase in test time due to the requirement that test conditions be iterated to achieve a given measurement result. In some

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TRANSMISSION ELECTROMAGNETIC TECHNOLOGY

TITLE: HIGH VOLTAGE TESTING, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Aero Propulsion Laboratory (AFWAL/PO), Power Systems Branch, Wright-Patterson AFB, Ohio 45433

OBJECTIVE: To obtain experimental data which will verify the applicability and realizability of the high voltage test specifications outlined in the engineering criteria documents and to perform component tests for the high voltage stator.

APPROACH: Perform tests on samples of insulating materials and components which duplicate the test requirements outlined in the engineering criteria documents. Develop a standard test fixture for performing tests.

PROGRESS: 820101-820531 In February the preliminary results of the testing and the proposed changes to the test specifications contained in this engineering criteria document (AFAPL-TR-79-2624) were presented at the 1982 High Voltage Workshop in Anaheim, Calif., and were well received by the technical community in attendance. The final report will be organized into separate volumes. Volumes 1, 2 and 3 have been written and are in final review prior to printing and distribution. Volume 1 contains the test program report, volume 2 contains the updated specifications and test procedures, volume 3 contains the generator test plan.

TITLE: HIGH VOLTAGE VACUUM ARC, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center Techniques Branch, Griffiss AFB, NY 13441

OBJECTIVE: The long range objective of this program is to develop a system to predict the onset of arcing in tubes used in high power radars in time to take corrective action. The objective of this project is to study phenomena that occur before arcing.

APPROACH: Certain phenomena that occur before a high voltage vacuum arc will be monitored in a test diode. These phenomena include light output from the interelectrode space and RF output from plasma oscillations.

PROGRESS: 810918-820518 Data from a series of vacuum arc tests have been recorded and analyzed. Measured were the total light level entering the photomultiplier tube through the 1.5 inch diameter test chamber window and the electrode emission current as the voltage across the electrodes

was increased in increments of two kilovolts until arcing occurred. The time development of the light output was also shown on a storage oscilloscope and photographed. The goal of finding precursory events signaling an imminent arc was obscured by two problems. First, with successive arcs, the local gas pressure at the electrodes was not held in the high vacuum range, i.e., below one ten-thousandth torr, because the single ion pump was inadequate. Thus the tests for vacuum arcing became invalid. Second, the photomultiplier tube cannot discriminate between the visible light that comes from gas glow and the X-rays that come from charges impacting on the electrodes. By covering the photomultiplier aperture with tape and observing no difference in light signal as a function of voltage, it was determined that X-rays dominated the light flux. Preparations are underway to rerun the experiment in a way that should remove the X-ray component from T.

TITLE: MICROWAVE ATE, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Naval Air Systems Command, Washington, DC 20361

OBJECTIVE: Establish procedures and methods for the determination and measurement of RF to microwave system testability to implement appropriate design and support considerations for densely configured microwave solid-state systems of the 1980-2000 time frame.

APPROACH: Determine the breadth of future applications and effectiveness of RF and microwave support systems. Develop support equipment and techniques to be utilized on a variety of current and proposed microwave systems which use solid state components. Determine which subsystem of proposed end items would lend themselves to advanced design application of built-in test or SCT capabilities.

PROGRESS: Literature reviews are completed. A purchase request was generated for a programmable multichannel microwave receiver to provide a base for laboratory investigations. Solid state device specifications were monitored for specific test capabilities. A desktop controller with graphics capability and IEEE 488 BUS interface to control and interpret laboratory experiments has been ordered.

ELECTRO-OPTICS TECHNOLOGY

TITLE: ADAPTIVE SPATIAL PROCESSING FOR COMMUNICATIONS RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center, Communications Transmission Branch, Griffiss AFB, NY 13441

APPROACH: Studies and investigations will be conducted in the application of adaptive spatial processing techniques to various communications systems. RADC in-house test and evaluation of experimental models of new adaptive spatial processors will be supported in the areas of development of test methodology, automated data collection/reduction analysis and associated software development and critical circuit fabrication.

PROGRESS: 810925-820325 Three main tasks were accomplished in the first 12 months of this effort. They are: (1) development of an adaptive SATCOM computer model, (2) system analyses of the EHF Satellite Adaptive Array Processor (ESAAP) and (3) fabrication and test of a covariance matrix measurement interface. The SATCOM computer model provides for system analysis of an adaptive phased array antenna and a multiple beam antenna system. The model currently contains the ability to produce freeze patterns and compute signal-to-back ground ratio improvement performance measurements as a function of both signal location and bandwidth. The model also includes the capability to analyze a one-tap or a two-tap adaptive array. A system analysis was performed, utilizing the SATCOM computer model, on proposed designs of ESAAP. Each design was evaluated for various jamming threats specified in the ESAAP statement of work. The covariance matrix measurement interface is an eight-channel receive system at UHF. Its function is to receive eight elemental signals, digitize them and transfer them to a laboratory mini-computer for processing. The system was designed, fabricated and tested. It will be installed in the near future.

TITLE: OPTICAL SIGNAL PROCESSING DEVICES, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center, Electro Optical Device Technology Br., Griffiss AFB, NY 13441

OBJECTIVE: The encompassing objective is to acquire and set up an Optical Signal Processing (OSP) laboratory and apply OSP techniques to C3 needs. Specific objectives include an investigation of the state-of-the-art of real time spatial light modulators, a determination of which C3 problems are solvable by OSP techniques and a demonstration of the advantages of (near) real time optical signal processing by applying OSP techniques to selected C3 problems.

APPROACH: A survey of equipment required to establish an OSP laboratory has been undertaken and the purchase requests of necessary items have been initiated. An investigation of available (near) real time spatial light modulators has been carried out and the purchase request for a coherent light valve has been initiated. As the ordered equipment filters in, fundamental experiments will be carried out to train new personnel. In cooperation with an outside contractor, Science Applications Inc., OSP applications to spectral analysis of wideband radar, spread spectrum communication, determination of radar ambiguity functions and stellar substraction (GEODSS program) will be studied. It is expected that the theoretical studies will be done by the contractor while the experimental program will be done in-house.

PROGRESS: 781001-790930 A laboratory capable of real time signal processing is now fully operational. Key items include a General Electric coherent light valve, an Itek PROM, a holographic fabrication facility, a PCM/TDM transmission set, various acousto- and electro-optical modulators, a diffraction plane sampling unit, a high resolution antimony trisulfide target video camera, a cadium selenide video camera, video monitors and an image analysis system. These items are being integrated to demonstrate real time synchronization of psuedo random bi-phase codes used in spread spectrum communications. The cross-correlation properties of optically processed raster recorded linear recursive sequences are being studied. Both coherent and noncoherent optical approaches to correlation processing are being pursued.

TITLE: COMPONENT/WAVEFRONT DIAGNOSTICS, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: AF Weapons Laboratory, Advanced Resonator-Optics Br., Kirtland AFB, N Mex 87117

OBJECTIVE: To develop new and refine existing laser wavefront diagnostic instruments and procedures, including techniques used for near field and far field measurement of advanced laser resonator output beams and techniques used for in situ measurement of figure errors of resonator optical components.

APPROACH: The existing laser wavefront analyzer will be operated and maintained, as well as upgraded to improve its hardware and software performance. A brassboard of the new high-speed wavefront analyzer, called HELIOS, will be evaluated, operated and maintained. Improved calibration techniques for both wavefront analyzers will be developed and evaluated. A recently conceived instrument for measuring the far field beam quality, called IRIS, will be tested, operated and maintained. Hardware and techniques for measuring key optical parameters of toric resonator mirrors will be developed, tested and operated, including an elipsometer for measuring polarization dependent reflectivity and an interferometer for measuring the combined figure errors of the resonator optics.

PROGRESS: 820217-820720 Technical management review was conducted 15 July 1982. The improved software for the laser wavefront analyzer has been reorganized to be more user oriented. A subtask is in the works to upgrade the laser wavefront analyzer for use in SIGMA/TAU tests. Diagnostic measurements to fully characterize the two new CO(2) gain cells are complete. The results showed some gain non-uniformity. These results will now be used as baseline data to make analytical predictions of resonator performance in upcoming experiments. In our first attempt on a half symmetric unstable resonator, the analytical predictions agreed quite well with actual measurements. At the present, an experiment is being conducted on the six-inch CO(2) gain cell to use computer controlled X and Y axis tilt feedback and backflat mirrors to optimize beam quality and power output.

TITLE: HOLOGRAPHIC ALIGNMENT BRASSBOARD, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center, Space Surveillance and Instn. Branch, Griffiss AFB, NY 13441

OBJECTIVE: The objective of this effort is to design, fabricate and test a holographic laser beam sampler alignment technique for short focus-to-diameter ratio (F-number), large aperture primary mirrors. These tests will establish the operational properties of this sampler alignment technique.

APPROACH: A holographic beam sampler alignment brassboard shall be developed and tested. After this, experiments which will provide a data base to characterize beam sampling, beam steering performance and other features, based on the holographic grating sampling and error sensing technique devised, shall be performed. Other experiments will be performed which, in conjunction with the results obtained in the previous experiments, will establish the operational properties of the brassboard in regard to beam sampling, and alignment sensing and control.

PROGRESS: 810319-810601 This effort has been completed satisfactorily. The holab grating was found to be very uniform in diffraction efficiency over its clear aperture. The measured RMS non-uniformity is well within the linear range of a typical wavefront sensor AGC. Only one area on the grating departed significantly from the average efficiency, and this departure of 0.5 percent absolute (7 percent relative) is small compared to the error budgeted for non-uniformity in fabrication. The remaining variations indicate a general trend of lower efficiency near the center; however, no statistically significant correlation could be found. This effort has been documented in RADC-TR-82-130, holographic alignment breadboard, May 82.

TITLE: AERODYNAMIC TEST AND ANALYSIS OF LASER SYSTEMS RDT&E CATEGORY 6.3

RESPONSIBLE DOD ORGANIZATION: AF Weapons Laboratory, Pointing and Tracking Branch, Kirtland AFB, N Mex 87117

OBJECTIVE: This effort supports the advanced radiation technology program by providing aerodynamic testing and analysis of laser systems and their components. The testing will be performed on the Airborne Laser Laboratory or in-house devices and in wind tunnel tests of scaled models. Candidate components for testing include laser devices, beam path conditioning systems, beam control systems, turrets, fairings and flow control systems. The results will enhance the design of laser systems and define the quality of internal and external flows.

APPROACH: The approach to providing aerodynamic support involves test and analysis. Testing encompasses the design and fabrication of test equipment and the acquisition, reduction and anlysis of test data. Data to be acquired will consist of flow visualization pictures, direct optical propagation measurements and hot-wire anemometry and pressure probe data. Analysis involves the use of the data, i.e., mean and fluctuating components of pressure, velocity, temperature, density, correlation length and phase aberrations to determine flow effects on high energy laser beam propagation.

PROGRESS: 820218-820722 Technical management review was conducted 25 Jun 82. Five additional subtask statements (SS) have been issued during this time period. The first was SS 01-03, which is an adminstrative SS. The second was SS 01-04 ,which requires the preparation of an integrated test plan. The third, SS 01-05, asks for the design of a high spatial and temporal frequency measuring device. The fourth, SS 01-06 , asks for the design of a low spatial and temporal frequency measuring device. The fifth, SS 01-07, asks for support in calibrating aerodynamic equipment. In addition, amendments to SS 01-03, 01-04, 01-06 were processed to better define the scope and adminstration of the SSs. SDL plans to brief the results of their design and test planning efforts on 20 August 82.

TITLE: LASER PUMPED FREQ STDS, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Rome Air Development Center, Electro Optical Device Technology Br., Griffiss AFB, NY 13441

OBJECTIVE: AF Function-Command, Communications and Control. Deficiency or opportunity: increasing data transmission rates require increased synchronization accuracies. Objective: investigate advanced techniques for new time and frequency standards. How research contributes: work should lead to improved time and frequency standards and to an understanding of the fundamental physical processes limiting their ultimate accuracies and stabilities.

APPROACH: The feasibility of using lasers to state-select atoms/molecules for use as new and novel time and frequency standards will be investigated. This is to be a joint in-house contractual effort.

PROGRESS: 800603-810731 A sodium atomic beam was designed, constructed and tested. Our Ring-Dye laser was tuned to D1 line using a sodium vapor cell and simultaneously locked to an optical cavity. The laser was then used to probe the atomic beam and sodiu D1 fluorescence was detected. By sweeping the frequency of the laser light we were able to measure the line-widths of the three D1 transitions between the hyperfine transitions of the upper and lower optical levels. They were found to be 10.4 plus/minus 0.4 MHz, comparing quite favorable with the theoretical width of 10 MHz. Next it was shown that it is possible to optically pump all of the atoms in the beam out of one of the ground-state hyperfine levels into the other, and to state-prepare the beam atoms. The laser was then locked to the doppler-free line of one of the three D1 optical transitions. In a second region along the atomic beam down-stream from the state preparation region, the atomic beam was irradiated by two co-propagating laser beams whose frequencies were separated by 1772 MHz. The second beam was formed by frequency-shifting a portion of the original beam using an acousto-optical modulator. A resulting non-linear raman transition between the two ground-state hyperfine transitions was observed in fluorescence. Its transit-time limited width was 600 KHz. Using the method of spatially separated oscillatory fields (i.e., two separated raman interactions) we were able to observe microwave ramsey fringes in accordance with our theoretical calculations. The transit-time limited widths of these fringes were 70 to 100 KHz. Calculations (both first and second order perturbation theory) indicate that effects such as light-shift and power broadening are greatly reduced if the separated oscillatory fields set-up is employed. A patent has been allowed. Also a paper describing the above, and pointing out the method's extension to the millimeter and far-infrared regions, was published in Optics Letters (June 81).

TITLE: CYCLE III DIAGNOSTICS, RDT&D CATEGORY 6.3

RESPONSIBLE DOD ORGANIZATION: AF Weapons Laboratory, Optics System Branch, Kirtland AFB, N Mex 87117

OBJECTIVE: The objective of the effort is to provide in-house experimental support for cycle III of the Airborne Laser Lab Program. Specifically, this includes such areas as gain mapping on the Cycle III laser, interformetry of the Cycle III laser and other experiments required to characterize the Cycle III optical system.

APPROACH: The approach of this effort is to study the Cycle III system, devise a detailed test plan, procure the necessary equipment, conduct the experiments and prepare reports on the results.

PROGRESS: 810129-810921 The Phase V testing of the ALL continues. Our involvement has been to characterize the HEL beam in the near-and-far-field, both on the ground and in the air. The laser has been successfully fired in the air and a comparison of the laser characteristics in the air and on the ground is on-going. To further our knowledge of the HEL, a flightworthy Scanning Hartmann Aperture Plate Experiment (SHAPE) is being built. This instrument will measure the laser beam wavefront aberrations in the near-field at the resonator. A large SHAPE is also under construction to measure the laser wavefront as it exits the near-field APT beam expander. A far-field point diffraction interferometer (3FPDI) has been built to measure the laser wavefront in the far-field.

TITLE: ARTO LASER FACILITIES SUPPORT, RDT&E CATEGORY 6.3

RESPONSIBLE DOD ORGANIZATION: AF Weapons Laboratory, Program Control Office, Kirtland AFB, N Mex 87117

OBJECTIVE: Provide instrumentation and optical diagnostics support to the advanced radiation technology office. Main areas of support for the Airborne Laser Laboratory include ground station instrumentation, laser diagnostics, propagation diagnostics, effects diagnostics, fuel farm support and optical modeling. This effort will result in completion of the Airborne Laser Laboratory Cycle II/IV and further understanding of laser systems, propagation and effects.

APPROACH: Contractor will design, fabricate and operate instrumentation that will provide data on the operation of the Airborne Laser Laboratory. The contractor will analyze portions of the collected data and recommend improvements for the instrumentation systems. Data gained will also be used to improve simulation models. The effort is directly related to the Airborne Laser Laboratory test schedule and, therefore, the support efforts will be paced by the test schedule.

PROGRESS: 81020-810715 Technical management review conducted 17 June 17 1981. Optical diagnostic equipment installed on-board the Airborne Laser Laboratory is being evaluated during flight tests. A new target board, for the TOW target, has been designed and is being fabricated. Installation of the oxygen-iodine laser is almost complete, some performance testing has been done. Testing of the pulsed DF and pulsar devices is continuing.

TITLE: E-O CALIBRATION TECHNOLOGY, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Naval Air Systems Command, Washington, DC 20361

OBJECTIVE: Development of methodology and equipment for support of weapon system test sets in the measurement and calibration of laser weapon systems.

APPROACH: Develop laser beam divergence and uniformity measurement on a per-pulse basis for characterization/calibration of target designator, rangefinder, illuminator systems and support equipment. Develop parameters for calibration measurements with respect to the divergence and uniformity of laser beams utilized in laser weapon systems and provide quantitative definitions of these parameters with recommended limits of uncertainty for primary standards. Investigate and recommend feasible approaches for accurately performing these measurements to achieve uniformity and standardization of calibration support. Perform test and evaluation of feasible approaches and develop calibration standards. To efficiently perform required pico-second laser pulse measurements of laser target designators and rangefinder systems, investigate and establish criteria for a single/multipulse detector with a response time on the order of a pico-second for use in pulsed laser metrology. Perform a feasibility study resulting in recommended approaches to the design and development of a prototype system leading to the establishment of a pico-second pulse calibration standard. Test and evaluate a developed prototype and establish calibration standards. Develop a prototype optical scattering measurement facility to be used to measure integrated scatter using either a coblentz sphere or a lens to gather the scattered light within a cone. This approach is to be used to establish measurement techniques and procedures for the specification of the character of high quality optical surfaces of ring laser gyros, laser optical systems and other systems in the ultra-violet, visible and infrared spectral regions.

PROGRESS: None. New program.

TITLE: IMPEDANCE AND RADIATION PATT. OF NMMW ANTENNA
RDT&E CATEGORY, 6.1

RESPONSIBLE DOD ORGANIZATION: ERADCOM Harry Diamond Center (HDL), Adelphi, MD 20783

OBJECTIVE: Investigate the radiation patterns and input impedance of representative NMMW antenna elements. Provide a complete antenna test facility at 94 GHZ. Design state-of-the-art leaky wave antennas.

APPROACH: (1) Evaluate potential measurement techniques to determine the best method and equipment for NMMW antenna measurements. (2) Fabricate and assemble equipment for test facility. Evaluate and calibrate test facility. (3) Use new and existing models, and design representative NMMW antenna elements. (4) Fabricate and test the antenna elements to verify design models and fabrication techniques.

PROGRESS: A complete program has been developed for the design of serie--fed microchip antenna arrays. The program was extensively tested and verified at lower microwave frequencies. Our millimeter wave antenna arrays was computed and fabricated, it is presently under evaluation.

TITLE: OPTICAL TESTING ANALYSIS, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: TECOM Technical Director and Chief Scientist, White Sands, NM 88002

OBJECTIVE: The primary objective of this work unit will be to develop methods for analysis of unique interference tests for testing specialized and unusual optical systems. Current test analysis limits the laboratory evaluation capability to standard type optical systems. Requirements exist to provide the capability for testing analysis of a new generation of optical systems that are not of standard classical optical design.

APPROACH: The approach will be to develop or invent analysis techniques for known requirements that currently have no solution.

PROGRESS: This year, the first of this work unit, was spent primarily getting the task organized and obtaining some manpower assistance. A twelve month temporary hire, GS-11 physicist was obtained in May and a GS-04 student trainee was brought on board for the summer in June. Initial analysis was directed toward evaluating the results of unusual shaped optical apertures (obscured, square, triangular, etc.).

TITLE: TEST TECHNOLOGY FOR ADVANCED E-O SYSTEMS, RDT&E CATEGORY 6.2

OBJECTIVE: Develop test technology for advanced electro-optical systems.

APPROACH: Investigate various advanced alternative concepts, such as application of thermo-optical properties of vanadium dioxide and the application of an infrared light valve tube for infrared scene generation, also pursue analysis, demonstration and system definition of the most promising concept which will provide a programmable target scene presentation which can be precisely controlled in intensity and position and which can be quickly modified. The presentation should also be capable of operation over a wide optical bandwidth to test neodymium yttrium aluminum garnet and carbon dioxide laser receivers, as well as mid and far infrared imaging systems. Investigate the feasibility of automatic analysis of video waveform signals from electro-optical systems to replace current manual interpretation of oscilloscope presentations in systems testing.

PROGRESS: A classified report, "Interim Report On Advanced Electro-Optical Ground Support," from Naval Weapons Center, China Lake, briefly discusses 12 areas of effort to improve testing capability for electro-optical airborn devices. It also discusses Navy R/D broad objectives to obtain improved availability of aircraft. The NAVAIR ATE program plan is reviewed. Some history of electro-optical avionics development and brief operational descriptions of airborne electro-optical systems is given. Brief functional and physical descriptions and configuration drawings of six AAM-60(V) electro-optical system test sets are given, as well as a listing of deficiencies of present electro-optical ground support equipment.

TITLE: ELECTRO-OPTICAL TESTING, RDT&E CATEGORY 6.3

RESPONSIBLE DOD ORGANIZATION: Eradcom Night Vision & E. O. Labs, Ft. Belvoir, VA 22060

OBJECTIVE: Technical objective is to establish a facility for the evaluation of electro-optical systems and components with emphasis on components and systems used for night vision applications. Maintain a knowledge of the latest state-of-the-art in electro-optical imaging.

APPROACH: Approach is to setup a laboratory to evaluate optical components and complete night vision systems. Perform an evaluation of all incoming systems and components to ensure compliance with specifications. Borrow newly developed components from manufacturers for evaluation.

PROGRESS: 8006-8105 Electro-optical testing during this period was primarily in support of technical evaluation of engineering change proposals for the AN/VSG-2 and AN/TAS 4, AN/TAS-5 and AN/TAS-6. Additional special purpose test equipment, white light interferometer, far infrared spectrophotometer, holograms and optical design analysis program have been ordered to expand the electro-optical testing capabilities.

TITLE: INTEGRATED OPTICAL SPECTRUM ANALYZER, RDT&E CATEGORY 6.2

RESPONSIBLE DOD ORGANIZATION: Naval Research Laboratory, Optical Science Division, Code 6570, Washington, DC 20375

OBJECTIVE: Design, fabricate and test Integrated Optical Spectrum Analyzer (IOSA) for electronic warfare applications. Device to have usable 40 DB dynamic range, bandwidth of 500 MHz and 1 GHz center frequency. Copies will be delivered for evaluation.

APPROACH: This program will be divided into two 9-month phases with initiation of Phase II contingent upon successful completion of Phase I. Phase I will emphasize the achievement of a 40 dB dynamic range device at a center frequency of 600 MHz. The contractor will address device integration and reduction at optical noise sources, utilizing existing geodesic lens fabrication technology and photodiode arrays. Phase II will increase the center frequency to 1 GHz.

PROGRESS: Design phase has been completed and lens fabrication is on-going. Difficulties have been encountered with obtaining laser diode with suitable in plane divergence angles. Lasers from RCA and Hitachi are being tested. Optical evaluation of Phase I device was completed by 1 October 1981. Program encountered more delays and optical evaluation of Phase I device has not yet been completed. Expect evaluation by March 1. New lenses tested and found to not transmit. New lenses were fabricated and optical test scheduled for June 82.

ACOUSTICS TECHNOLOGY

TITLE: TRANSDUCER CALIBRATION FOR ACOUSTIC EMISSION AND NDT RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Office of Naval Research, 412, Arlington, VA 22217

OBJECTIVE: NBS is attempting to devise accurate methods for calibration of acoustic emission and ultrasonic testing transducers. Acoustic emission measurements promise to become a useful method for nondestructive testing of Navy structures, such as pressure vessels, and ultrasonic testing of many Navy materials and structures is required to ensure integrity and longevity.

APPROACH: Ultrasonic nondestructive evaluation and medical transducers are being calibrated as sources radiating into water by means of a modulated radiation pressure method. A method for calibrating acoustic emission transducers is being developed which utilizes an elastic theory solution to the problem of a step function load applied to a semi-infinite solid.

PROGRESS: The acoustic emission transducer calibration facility which utilizes the surface pulses generated on the surface of a large steel block was used to perform 65 calibrations. The radiation pressure apparatus has been used to calibrate 24 transducers. Improvements were made in the design of a conical acoustic emission transducer and development of a theory for the transducer was begun. (F.R. Breckenridge and M. Greespan, 'Surface-wave Displacement: Absolute Measurements U·ing A Capaitive Transducer,' J. Acoust. SOC. AM. 69, 1177-1188 (1981).

TITLE: ACOUSTO-OPTICS, RDT&E CATEGORY 6.1

RESPONSIBLE DOD ORGANIZATION: Office of Naval Research NRL Non Special Focu Program, Washington, DC 20375

OBJECTIVE: Development of new and improved techniques for visualization of acoustic fields and underwater objects. Utilization of acousto-optic techniques coupled with digital signal processing for non-destructive investigations, material studies and sound detection and characterization. This work is related to (1) underwater object search, characterization and imaging, (2) nondestructive flaw visualization, (3) fabrication of special materials and (4) sound transducer development. Success will lead to: new and improved methods of sound field detection and identification, object recognition and acoustic silencing; improved acoustic and optical materials; and improvement of NDE techniques.

APPROACH: Schlieren, projection imaging and interferometry systems are combined with digital computer based picture processing techiques for quantative characterization of acoustic signals and to develop new and improved capabilities to detect and identify sources and scatterers of sound. Acoustic near-field holography and scanned heterodyne interferometry are utilized to determine the characteristic low frequency motions of driven bodies.

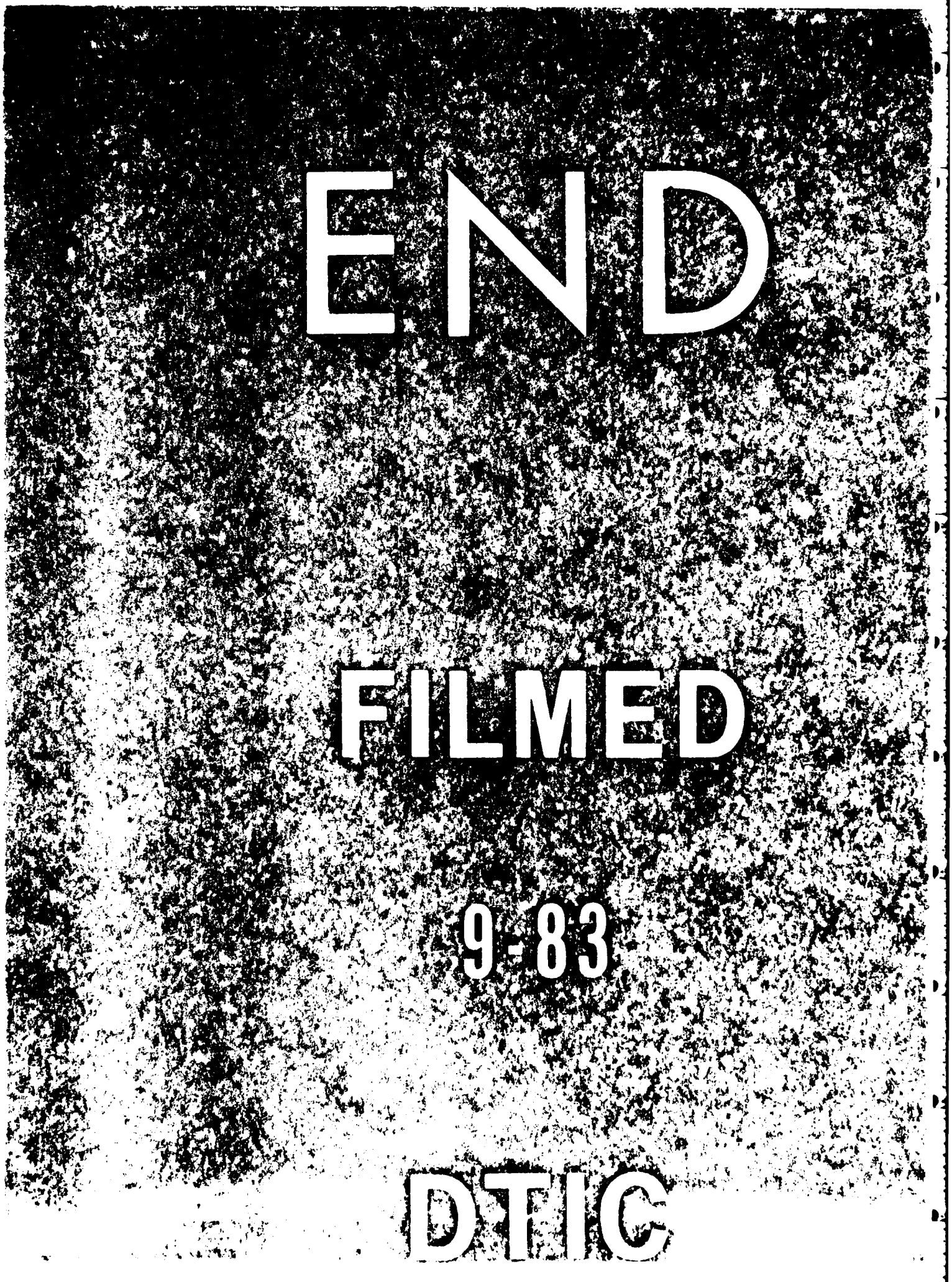
PROGRESS: Completed acoustic ramp response study and submitted papers; evaluated sensitivity of optical techniques of low-frequency visualization.

TITLE: UNDERWATER ACOUSTIC METROLOGY, RDT&E CATEGORY, 6.2

OBJECTIVE: Follow new research and development in underwater acoustic surveillance systems and conduct a parallel effort in sonar standards and measurement techniques. Current thrusts (defined by studying the undersea target surveillance strategies) include: (1) extending low-frequency calibration capabilities, (2) extending near-field calibration array high-frequency limits for high-resolution sonar.

APPROACH: Low-frequency calibration sound sources and hydrophones, signal processing techniques and low-frequency calibrators will be explored to make complex (amplitude and phase) hydrophone calibrations to lower frequencies than is now possible. The use of piezoelectric polymers in near-field arrays is being investigated.

PROGRESS: Completed construction of A 1-to 10-Hz hydraulically powered calibration sound source. Completed development of a new waveform control system for use down to 0.1 Hz in USRD'S high-pressure tube calibration facility. Completed development of a 5-to 50-kHz, synthetic, cylindrical near-field calibration array for use in USRD'S pressure tank measurement facility. Successfully tested prototype constant beamwidth transducer usable from 20 to 140 kHz.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